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# OFFICE OF TECHNOLOGY ASSESSMENT REPORT "COMPETING IN MANUFACTURING"

## HEARING

BEFORE THE

## COMMITTEE ON BANKING, HOUSING, AND URBAN AFFAIRS UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

ON

THE OFFICE OF TECHNOLOGY ASSESSMENT'S REPORT, "MAKING THINGS BETTER: COMPETING IN MANUFACTURING"

FEBRUARY 28, 1990

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# OFFICE OF TECHNOLOGY ASSESSMENT REPORT "COMPETING IN MANUFACTURING"

WEDNESDAY, FEBRUARY 28, 1990

U.S. SENATE,
COMMITTEE ON BANKING, HOUSING, AND URBAN AFFAIRS,
*Washington, DC.*

The committee met at 10 a.m., in room SD-538, Dirksen Senate Office Building, Senator Donald W. Riegle, Jr. (chairman of the committee) presiding.

Present: Senators Riegle, Dixon, Shelby, Bryan, Garn, Heinz, D'Amato, and Pressler.

## OPENING STATEMENT OF CHAIRMAN RIEGLE

The CHAIRMAN. The committee will come to order.

Let me invite our first panel of witnesses, Mr. John Gibbons, who is going to be accompanied by two people that he can introduce and we are delighted to have all of you here.

I have some opening comments that I want to make and will do so at this time.

I think this is a very important hearing today, and it brings forth and presents some very important information that has been developed carefully over a period of time. There is no issue that I consider more important to the American people or the American future than our Nation's competitiveness in today's global marketplace and what the trendlines show for the future.

Clearly the standard of living for our people, our political influence in the world, and ultimately our national security depend upon how well our industries, both in manufacturing and in services and financial services compete in an increasingly integrated world economy, and that is why this topic is and will continue to be a fundamental theme of my chairmanship of the Senate Banking Committee.

During the last year our committee spent a very substantial amount of time putting together and then enacting the savings and loan reform legislation and set up the monitoring mechanisms to keep track of the implementation of that legislation. During that year we also, among a number of other things, held five hearings to examine concerns that have been expressed by many responsible Americans about the state of our country's industrial technological and financial base.

Testimony by key witnesses at those hearings suggested that we are currently witnessing important economic trends that could signify a substantial reduction in our country's influence in world af-

fairs. These witnesses confirmed what John Young of Hewlett Packard, the chairman of President Reagan's Commission on Industrial Competitiveness, told the President in a 1985 report in which he warned—he and the other members of that commission—"that America's ability to compete in world markets is eroding." And that such erosion must be arrested because "a strong industrial base is vital to our national security." That was a finding of that very distinguished panel. Of course that goes back now 5 years.

Concerns about our country's industrial and financial competitiveness are directly relevant to legislation that this committee will consider this year such as the Defense Production Act, the Export Administration Act, and the Fair Trade in Financial Services Act.

Furthermore, the committee also has responsibility for export promotion, exchange rates, and general international economic matters that affect the ability of our companies to compete in the international marketplace. These are all matters that the committee will focus on increasingly during the course of this year.

I am very pleased that our committee will begin its 1990 hearings on competitiveness by having the Office of Technology Assessment release to us its new report, "Making Things Better: Competing in Manufacturing." This very important piece of work was initiated in 1986 at the joint request of my colleagues seated with me here, Senator Garn and Senator Heinz who were then respectively the chairman of the full Banking Committee and the chairman of the International Finance Subcommittee.

OTA states on page 1 of its report "that American manufacturing has never been in more trouble than it is today. Its biggest challenge is from Japan." I just excerpt those quotes for now. While noting that other nations are responding to the challenge from Japan as nations, the report states that our country is not because the American "Government is dozing at the switch."

America must respond as a team to the mounting challenges that are facing us, and I think today's OTA report really underscores that need to conceptualize and put together a kind of team-America response as to how we make a surge in our productive performance and close some of these enormous gaps that have opened up on the international level.

I want to make just one very quick reference to this chart, if it could be handed over to me. My colleagues have seen a variation of this chart from time to time, but for those of you in the audience, this is one of a series of charts, but this particular one expresses the net international investment position of the United States over the last several years and it shows from this zero line or this crossover line how the United States has gone from being a creditor nation about the mid-1980's down into the debtor nation status, but our international competitive shortfalls have caused us to ride these trendlines down through the end of 1988 and the three quarterly add-ons that are available and have been posted for 1989. But it shows a dramatic change in American position vis-a-vis the rest of the world and a very dangerous situation. We are adding international debt at the rate of $1 billion roughly every 3 days.

We all look at charts all the time and it's very hard to find one that——

Senator HEINZ. Mr. Chairman, the only thing that seems to be going down faster than our credit rating is communism.

The CHAIRMAN. Well, that's exactly right. I think that's probably true and the problem that we don't want to have is the situation where we are not in a financial position internationally to really take advantage of these massive changes. For example, we have just seen forces we have supported winning an election in Nicaragua and it's not clear that we have got the money and the resources to come in there and Poland and other places the way we might like, partly because we have let our own economic competitive position deteriorate very badly.

In any event, let me put this aside and just conclude as follows. The witnesses that we have invited to comment on the OTA report at today's hearing are Dr. Ross, president of AT&T's Bell Laboratories, who was also a member of that presidential commission on competitiveness; and Mr. Sanford Kane, the former president of U.S. Memories. They, of course, are in the news again today as a company, and are two very distinguished observers that will follow the presentation of the report.

We are honored to have them with us this morning and we very much look forward to hearing Dr. Gibbons present the OTA report and to the testimony of Dr. Ross and Mr. Kane. I again want to particularly thank and commend Senators Garn and Heinz for their leadership and foresight in asking OTA at some distant point in the past to conduct this very elaborate piece of work, the results of which we have before us today.

Let me yield now to Senator Garn.

Senator GARN. Thank you very much, Mr. Chairman.

I, unfortunately, in a few minutes have to go to another hearing so I would simply ask that my statement be included in the record so that I'll have more time to listen to Mr. Gibbons.

The CHAIRMAN. Very good.

## OPENING STATEMENT OF SENATOR GARN

Senator GARN. I would like to welcome our panelists today to discuss the competitiveness of the U.S. manufacturing sector and to recommend what we as a nation should do to improve our competitiveness. In 1986, together with Senators Heinz and Packwood, I requested the OTA study of the U.S. trade deficit, the second part of which is the basis for today's hearing. OTA's 1988 study, "Paying The Bill", found a broad range of causes for U.S. trade problems but highlighted one in particular: Declining Competitiveness.

The report released today argues that the Government should take a broad range of steps to provide a supportive environment for manufacturing. OTA urges reducing Federal budget deficits and encouraging R&D. I certainly agree with those ideas and note that the 1991 administration budget proposes increases in R&D funding. However, tax policy does not support R&D and long-term investment nearly enough.

OTA also suggests specific changes in Government/industry interaction to promote competitiveness. I have no fixed views on how our procurement policies, reearch funding, antitrust policies and others might be amended, but welcome the opportunity to look

at the issues raised by this report. I would like to see how Government/industry cooperation could be improved so we can make U.S. manufacturers more competitive.

The CHAIRMAN. Senator Shelby.

Senator SHELBY. Mr. Chairman, I have an opening statement that I'd like to also be included in the record. Other than that, I'd like to hear the witnesses.

## OPENING STATEMENT OF SENATOR SHELBY

Senator SHELBY. Mr. Chairman, let me commend you for scheduling this morning's hearing on a most important subject.

I have read only a brief draft of the report presented today by the Office of Technology Assessment and yet these few short pages were enough to make me angry and frustrated.

I am not mad at the OTA—they appear to be doing an excellent and thorough job in determining why and to what extent we are losing our lead as a global leader. I am mad because the answers are so obvious and yet we need a study commissioned to identify them and what is worse, we'll probably end up commissioning another study to tell us how to respond.

The first, and I would ague, single most important problem is that of the budget deficit. The dissavings effect of our enormous budget deficit has driven up the cost of capital in this country to levels much higher than that in competitor nations—the study says capital costs are as much as 50 percent higher here, my research says 100 percent; hardly a neglible difference but the result is the same. It is simply more difficult—more expensive and more risky, for a U.S. company to research and develop new products, invest in superior production technology, improve productivity.

The report suggests that additional tax incentives are also warranted to encourage appropriate investments and strategies by businesses—specifically R&D and plant and equipment investment, and commercialization. I agree wholeheartedly, and would only add ending the double taxation of dividends, and a differentiated capital gains structure.

The report stresses the shortcomings of the American work force—workers are poorly educated and inadquately trained to handle today's technology. Education must be one of the most pressing priorities. However, the deficit demands creative, cost-effective solutions and I believe that we must leverage State and private funds and encourage more initiative on the part of businesses and communities.

The report stresses the benefits of Government and industry working together. I believe that the Government can do more to assist and encourage the rebuilding of this Nation's industrial base and that public-private partnerships may be warranted, particularly in industries needed to maintain military strength. But I am a firm believer in the power of market forces and I believe that U.S. industry can compete, given a more benevolent financial environment and a less adversarial relationship with government.

I appreciate the work of the OTA and I look forward to hearing more of their findings.

The CHAIRMAN. Very good. Senator Heinz.

## OPENING STATEMENT OF SENATOR HEINZ

Senator HEINZ. Mr. Chairman, I have an absolutely penetrating, brilliant opening statement. I'm going to have it distributed to those eager people over at the table to save time for John Gibbons.

I just want to commend John and his wonderful staff, Dr. Gorte and Ms. Gillman, for their usual extraordinarily clear, comprehensive and thoughtful analysis. This time building upon "Paying the Bill," how we can start paying the bill by getting a better handle on our problems.

What the report really lays out and talks about in sum and substance is what our Government has not done and what we must do if we are going to approach the question of critical sectors of our economy systematically.

The other significant thing the report says is that what we have now is industrial policy, but it is industrial policy by accident, by crisis or expediency. That, of course, is worse than no policy at all. It is the squandering of resources—time, effort, money—without any discernible purpose. Yet, as the report points out, there are great success stories where we consciously focused our efforts, as in agriculture, as in aircraft, and certain subsectors of semiconductors, microelectronics.

Other countries are employing sophisticated, successful industrial targeting techniques. Maybe we all wish that that wasn't happening. Maybe we wish we could return to the simpler world of Adam Smith and David Ricardo, but the fact is we live not just in interesting times but in current times and they are different than what the economists at Yale University and Harvard and MIT and Stanford and Chicago tell us the world is supposed to be like.

As soon as our academic community reads some of the OTA's excellent work and wakes up to the fact that the world is not as they have been teaching it to their students for the last 20, 30 or 40 years, the sooner we will get some of the intellectual leadership from our academic community that is so profoundly lacking and which should be an embarrassment to the president of every university, to the deans of the schools of economics, and to the faculty, particularly the tenured ones.

Thank you.

The CHAIRMAN. Thank you, Senator Heinz.

Senator Bryan.

Senator BRYAN. Mr. Chairman, I'm going to defer an opening statement and listen to the witnesses and use my time for the purpose of questioning.

The CHAIRMAN. I would just make one more observation in relation to comments that Senator Heinz has just made, and to which I agree, and that is the retiring chairman of the Ford Motor Co., Don Peterson, is quoted in today's press as reflecting deep concerns about our inability to really face up to and face off with the competitive challenge internationally, particularly with Japan. He makes some compelling points about that and I intend to invite him to come and testify at an early date so that he and others can get into this discussion and we can continue to work this issue so that we decide what needs to be done and how we force those actions to occur.

With that, Mr. Gibbons, we are delighted to have you, and if you would—we've made reference to both of your colleagues, but if you would like to indicate to us their roles and then we'd like to hear from you.

Before we begin I have a statement for Senator Dixon.

## OPENING STATEMENT OF SENATOR DIXON

Senator DIXON. Mr. Chairman, this morning we will hear from the Office of Technology Assessment on the state of American competitiveness with respect to manufacturing. I fear that we will not be happy with what we hear today.

Unfortunately, we don't have to look far to see the effects of America's manufacturing slide. The big three auto makers now include the name 'Toyota', the vast majority of consumer electronics are produced off shore, and our defense industry is becoming more and more dependent on foreign manufactured semiconductor devices. In fact, foreign competition has invaded almost every manufacturing aspect of American business.

The loss of American competitiveness has not taken place overnight and will not be corrected in the near future. We must, as a nation, face up to the detrimental long term affects of continuing business as usual—that of becoming a second class player in the world economy.

It will take a unified approach to reverse the negative competitiveness drain on America. Business must convert to a long term strategy and abandon the "Live For Now" attitude so prevalent in today's society. The Government must pass legislation that helps to incentivize both the business community and itself to invest in America's future.

It is also time to take a hard look at our trading partner's responses to our positions on free trade and open markets. America can not alone continue to pay the price for cleaning up the environment and providing a safe work place by losing its manufacturing capability to less conscientious nations. We must strive to formulate a less legalistic but more results oriented trade policy.

I am very concerned over the increasing dependence on foreign components in America's defense products, which I have offered solutions to through amendments to the Defense Production Act. We can not allow American defense preparedness to slip to the point where we have to wait in line to buy components for our weapon systems from off shore sources. Similarly, we must create incentives for investment in modern manufacturing facilities and processses—the very subject of todays hearing.

I would like to take this opportunity to commend the chairman for holding today's hearing. I look forward to the testimony of our distinguished witnesses.

## STATEMENT OF JOHN H. GIBBONS, DIRECTOR, OFFICE OF TECHNOLOGY ASSESSMENT, ACCOMPANIED BY JULIE GORTE, PROJECT DIRECTOR, OTA, AND KATHERINE GILLMAN, DEPUTY PROJECT DIRECTOR, OTA

Mr. GIBBONS. Thank you, Mr. Chairman.

I am pleased to introduce the project director, Dr. Julie Gorte, on my left; and the deputy director, Katherine Gillman, on my right, who have done an excellent job for the agency and we are delighted that the committee has chosen a full committee hearing for the release of this document.

I would submit for the record my testimony and only try to summarize some things from it, if I may. I would also like to refer to some of the charts attached to the testimony because a picture is sometimes worth a lot of words.

The CHAIRMAN. We will make the full report a part of the record and we will proceed as you've suggested.

Mr. GIBBONS. Thank you, sir.

You know, we hear a lot about post-industrial society and service economy and the likes, but manufacturing indeed does remain at the core of our economic strength and hopes.

In 1960, 23 percent of our expenditures as consumers went to manufactured goods. We have been moving toward an information society, but that 23 percent has now increased to 30 percent. So I think we sometimes tend to diminish the central importance of manufacturing in our economy.

It accounts also for a very disproportionate number of our well-paying jobs in our society, and that we tend to lose account of from time to time.

Now because we've been traditionally a manufacturing nation, we've built the highest standard of living in the world and we still enjoy that fact. But the fact also is that our lead is slipping and it's slipping seriously compared to other countries.

We provide in our report some evidence. For example, the chart labeled chart No. 2 in my testimony shows clearly what is happening to our manufacturing and merchandised trade balance. Since about 1980 it has plummeted despite major adjustments such as devaluation of the dollar in 1985, and obviously we're still in the pits.

But why is this the case? I would give you three symptoms. First of all, the low productivity growth, which is shown in chart No. 3 in which U.S. productivity gains in the period 1960 to 1988 are compared with the productivity gains of other countries, and you see that the United States lies at the bottom of the ladder compared to a substantial number of our trading partners.

The CHAIRMAN. Before you move on with this chart, this chart would indicate this trend between the years of 1960 and 1988. So, this is a 28-year time series, during which Japan, for example, was showing an annual productivity growth rate of 7.8 percent.

Mr. GIBBONS. Per year.

The CHAIRMAN. Per year, and over the same time period we were showing a rate of 2.8 percent; is that right?

Mr. GIBBONS. That's correct, Mr. Chairman.

The CHAIRMAN. So they were running 5 percentage points per year each year over that 28-year span on the average higher than we were in productivity improvement?

Mr. GIBBONS. That's correct.

The CHAIRMAN. And Italy, I see, comes in at 5.5 percent, France at 4.9 percent and so forth and, as you say, we're down at the bottom of the list with a annual rate of 2.8 percent.

Mr. GIBBONS. That's correct, Mr. Chairman, and this over a period of time as it rolls forward. If it happened only in 1 year, you might be able to manage that, but when it happens again and again and again and the average piles up on you, it becomes a very serious state of affairs before very long.

Let me give a second symptom. The next chart attached to my testimony has to do with nondefense R&D expenditures as a percent of GDP, and you see this indicates that the United States compared to in this case Japan and West Germany has had a comparatively low investment rate over a long period of time, and that again has momentum that gathers over the years as those countries constantly invest a greater percent of their GDP into R&D expenditures.

The third symptom is the next chart, which again compares the low investment in machinery and equipment that has been going on in the United States and in fact in West Germany, in France and the United Kingdom compared to the extraordinary exception of Japan, which over these years has constantly rolled in a very much higher rate of investment in machinery and equipment. For Japan this has been going on now without exception for 20 years.

Well, much of the difference that one can attribute to this between the different countries has to do with the presence or absence of Government activity involvement in the process of civilian economy development, and the implications of a continuation of these sorts of trends are very, very significant, first of all, for our national security because we know that increasingly our military capabilities, our national security depends upon civilian technology. It draws upon that technology in an increasing manner.

It also has implications for our maintaining our civilian economy with good and productive jobs.

And, finally, it obviously has implications for us in terms of restoring a healthy balance of payments.

Well, the Chinese have a proverb that says, "if you don't change the direction you're moving, you're liable to end up where you're headed," and Thomas Jefferson said, "that sometimes a change in direction means the right course, that the right course does mean a change in direction."

So we're talking today about possible changes and emphasis or direction, and in our paper we mention four areas for action. The first chart that was attached in my testimony summarizes those four, and I'll go quickly through those.

Incidentally, I would say at the start that not one of these things can bail us out. It's going to take some kind of combination of these sorts of things over an extended period of time in order to turn things around.

The first general area for action is improving our financial environment. Our Federal deficit, as you know, is serious. It seems intransigent almost, and if the Federal deficit can be reduced, then there are more dollars available for investment in the private sector in our production sector. A lower Federal deficit means a lower cost of capital to us ultimately.

Chart No. 6 attached to my testimony summarizes the issue of savings. Household savings as illustrated in this chart show that

we're in awful shape compared, for instance, to Japan. I believe last year Japan's savings was three times American savings.

When you save it gives money for long-term investment, and that means machinery and factories and production capabilities.

The next chart shows the cost of capital, which is ultimately a terribly influence on management decisions and on industrial decisions about making investment. If the cost of capital to do research or to buildings or to build equipment is consistently higher than that of our competitors, then we know who has the advantage and the opportunity to gain in an intensely world competitive market.

So in improving the financial environment we need to encourage lower interest rates that come from lower deficit spending, more patient capital and more focus on long-term investment. This has implications for capital gains treatment, and it also has implications for discouraging the kind of churning that goes on in the markets by institutional investors, which in turn caused managers and decision-makers to focus more and more on near-term performance and less and less on the long-term outcome of their investment.

The next chart, which is No. 10 in the attachments, summarizes what has been happening to our real interest rates in the United States. This is the interest rate that is charged after you subtract off inflation. And you will note that there has been an extraordinary rise since about 1980 to values of our interest rates which now put us at a disadvantage compared to other countries around the world.

So there are a variety of things we suggest in our report that can be done to improve the financial environment so important for investment decisions.

The second is to upgrade education and training, and you have two charts in my testimony. Charts 11 and 12 are the two that I would refer to. Chart 11 summarizes 12th grade achievement scores in advanced algebra, and you see we're just above Thailand at this point. We are way down the list in terms of how well we're doing with respect to other countries. This is K to 12.

If you look at chart 12, which is spending for education for grades K to 12 as a percent of our GDP, you find also that we're way down the list.

Well, these are only indications. It doesn't say necessarily that more money will do the job, but it does give us a clear indication that we're perhaps not giving enough attention to this very fundamental thing of building our human resource capital, our human infrastructure in this country.

The CHAIRMAN. Just as an aside as we're going through these, what was the rationale behind picking advanced algebra at the 12th grade level of achievement as being the one of many possible things to pull out as a yardstick on achievement?

Mr. GIBBONS. We could have taken geometry. We could also have talked about literacy. There are any number of measures. I picked algebra because I thought it is indicative of the very fundamental tools needed by the modern versatile worker in an industrial high-technology society. If you can't add, subtract or do simple arithmetic, you're in trouble compared to your competitors and that's just where we find ourselves. We find ourselves with people trying to

build a factor and meanwhile having to re-educate the workers to get them up to an eighth grade mathematics capability, and that's a drain on the industry and it's a sad thing that our schools are putting out people with that kind of training and that we as parents allow it to happen.

The CHAIRMAN. I take it that if we had selected other subjects or ways of getting at this in terms of science or English and things of that kind, we would see comparative shortfalls about the same.

Mr. GIBBONS. When you focus on grades K to 12, which is the worker of the 1990's in the turn of the century, that's the case. Now the better news is, and I didn't come to give you the good news necessarily, but the better news is that in colleges and universities we're doing a better job of educating and we are spending and we've very competitive. Our engineering schools are half filled with non-U.S. citizens.

But K to 12 is our seed corn. That's where our workers are going to be coming from, and if you miss there, then the industrial guys or the universities are going to have to try to make up for it, and that's not right.

The CHAIRMAN. Why don't you continue.

Mr. GIBBONS. Our third point is diffusion and access to manufacturing technology, and we do cover in our report a review of some very encouraging things that are happening on an ad hoc way around the country. Several States are actively involved in this, some of the national labs are involved in new arrangements with industry and things are beginning to improve, but the extent of this activity, encouraging as it is, has to be measured against what is happening in Japan and other countries where the activity is much more intense, much better organized and much more resources flowing in there.

And, finally, the fourth approach we mention in our report is the support of research and development for commercially important technologies. Here one can draw of course analogies to the Defense Advanced Research Projects Agency where flexible and long-term support is provided with a core group of analytical people who in turn spend a lot of money with industry and universities in areas such as SEMITECH and high-definition television.

There are arguments of course about the Government picking winners and losers as one approaches the marketplace of commercial technologies, but I believe honestly, Mr. Chairman, that that argument is specious.

First of all, there is a clear history of the U.S. Government investing heavily and over a long period of time in commercial technology, such as agriculture, civilian aircraft, electronics and computers which have been significantly successful.

So I think we should get aside from that argument and talk about what the other countries that are competing so well with us now, and in fact they're beating us, what have they been doing. They have been actively involved in just this sort of civilian sector technology agency assistance.

It seems most timely to us that it is propitious for us to learn the lessons from our past and also the lessons we're learning from our competitors and create some kind of civilian technology agency that would work closely with industry and entrepreneurs in the

private sector, it would have major cost-sharing by the private sector which provides us in a sense a market discipline to the process and it would invest in selected areas that could enable the United States to pull out of this nose dive we're in.

Now we could talk about the sorts of things they would work on and how it might be organized, but we believe unless one organizes it explicitly and with authority and commitment, long-term commitment, then we may move ahead, but the other fellows are moving faster.

So in summary, Mr. Chairman, we believe the situation is very serious. We think there are no magic bullets and wishing won't make it so. But there are at least these four approaches and there may be some more which if taken together and given time and commitment can do the job and we can pull out of the nose dive, but it isn't going to happen without a lot of work and time.

Thank you, Mr. Chairman.

[The complete prepared statement of John A. Gibbons follows:]

STATEMENT OF

DR. JOHN H. GIBBONS

DIRECTOR

OFFICE OF TECHNOLOGY ASSESSMENT

BEFORE THE

COMMITTEE ON BANKING, HOUSING, AND URBAN AFFAIRS

UNITED STATES SENATE

February 28, 1990

Making Things Better: Competing in Manufacturing

Mr. Chairman and members, we appreciate the opportunity to appear today to release our new report, Making Things Better: Competing in Manufacturing. With me today are Dr. Julie Gorte, the Project Director, and Katherine Gillman, the Deputy Project Director.

The study was requested originally by Senators Packwood, Heinz, and Garn, on behalf of the Senate Committee on Finance and the Senate Committee on Banking, Housing, and Urban Affairs. The House Committee on Banking, Finance and Urban Affairs later added another request for the study. The report you are releasing today is the second in a series of three. The first, entitled Paying the Bill: Manufacturing and America's Trade Deficit, was requested by Senator Heinz and published in summer 1988. That report concluded that American manufacturing technology and competitiveness must improve in order to eliminate the trade deficit without substantial harm to American standards of living. The report we are releasing today, Making Things Better, provides analysis of and options for improving manufacturing technology.

## SUMMARY

The problems of American manufacturing are deep and systemic, and it will take the combined efforts of government and industry to repair them. For years, American manufacturing has been losing out in the development, diffusion, and commercialization of technology in manufacturing to Japanese manufacturers, who have in many ways rewritten the book on production. To a lesser extent, West German, Taiwanese, and Korean manufacturers have also demonstrated superior technology development and diffusion in many sectors. If we do not take steps to solve the problems of American manufacturing, its competitiveness will continue to decline. This will hurt American standards of living and our ability to provide for national security, and it will leave the U.S. with a chronically high trade deficit and an addiction to foreign capital.

Government can help in four areas. First, America's financial environment is not supportive of long-term investments in R&D and capital acquisition, compared with Japan and West Germany. The United States has significantly higher capital costs, and recently the added pressure of hostile-takeover threats, has further discouraged long-term investment. The most effective step Government could take to improve the financial environment is reducing (and eliminating, in a few years) the budget deficit. Other options include tax policies and other measures to encourage higher private savings rates, to reduce the costs of specific investments like research and development and capital equipment, and to encourage longer-term holding of equities on the part of institutional investors.

The quality of human resources is a growing problem. Young people in America are graduating with weak math, science and reading skills, and many midcareer workers are unprepared to cope with computer readouts and digital analysis required in

automated manufacturing. The most pressing need is for improvement in public education across the board, but this will take years to yield results. In the interim, Congress could consider several options to encourage employers to provide and workers to take additional training and education. A specific need is to keep the engineering pipeline filled. While there is not now an obvious shortage of engineers in manufacturing, there could be problems in the future. The supply of white males--traditionally, the major demographic source of engineers--is shrinking. Unless we find better ways of encouraging women and minorities to enter engineering, it may be more difficult to attract and afford competent engineering talent in manufacturing. Here, too, the best option is to improve math and science education in primary and secondary schools, but there are interim options, including providing midcareer training for engineers and greater Federal support of manufacturing engineering research.

Another major problem is the difficulty of diffusing knowledge throughout manufacturing. Most large companies are dependent on the quality of products delivered by small companies that supply parts and machinery, yet many of the nation's 355,000 small and medium-sized firms have trouble keeping up with technological advance. Both the Federal government and several States have fledgling efforts to provide industrial extension services that offer competent technical support and referral to appropriate training and sources of supply. This commitment could be deepened at all levels by providing additional funding for expanded services. Financial support for implementation of the advice given by the extension service, in the form of loans or loan guarantees or subsidized equipment leasing, is another option.

Finally, government could consider broadening its support for specific technologies. With America's high-cost capital and short-term focus, many of the investments needed to keep up with the competition in developing many technologies is prohibitive for even the largest American companies. Governments in most other

advanced and many developing nations provide extensive support for technology development and diffusion in areas considered particularly important for civilian manufacturing competitiveness. While the debate over the propriety of government's "picking winners" is not resolved, American history contains numerous examples of successful government support of critical new technologies, including civilian aircraft, agriculture, and computers and microelectronics. There are several failed attempts as well, and we can learn a great deal from those about how to avoid future pitfalls. In order to pursue a coordinated, active policy of support for high-risk but promising new technologies, the government will need to build an institution (a civilian technology agency) that could work closely with industry and experts to select and support promising technologies.

None of these steps alone is enough to make a dramatic difference in the short term. They need to be taken in some combination, and given enough support and time for the effects to be seen. Even then, they might not be enough to boost American manufacturing to the standards of other advanced nations, nearly all of which are doing much more to support industrial competitiveness. But without strong, positive steps to support manufacturing technology and competitiveness now, the decline will continue.

* * *

American manufacturing is in deep trouble. (See attached graphics.) We have fallen behind many of our competitors in developing, commercializing and diffusing technologies, and we will continue to lag unless government and industry act together to change the situation. The signs of weakness in manufacturing are everywhere: productivity growth is sluggish compared with other advanced and developing nations; the nation is increasingly dependent on foreign producers for the machinery and tools

needed to produce goods and services; the trade deficit remains stubbornly high despite significant dollar devaluation five years ago. These weaknesses must be repaired if the nation is to provide rising standards of living for its citizens.

Manufacturing is important to U.S. standards of living for many reasons. The United States cannot do without a strong manufacturing sector; demand for manufactured goods, in terms of its percentage of GNP, is stronger than ever. American consumers, businesses and government devote over 30 percent of all their spending to manufactured goods (other than food and fuel), compared to 23 percent 30 years ago. Services have not taken the place of manufacturing, nor can they. Manufacturing and services are interdependent; many service industries depend heavily on manufacturers for business and for supplies, and manufacturing could hardly exist without support services. We cannot have competitive service sectors without manufacturing, and vice versa. Moreover, manufacturing is still an extremely important source of employment. Nearly 28 million Americans owe their jobs, directly or indirectly, to manufacturing. Manufacturing accounts for a disproportionate share of well-paid jobs, and the service jobs that depend on manufacturing are also relatively highly paid. To keep those good jobs, America has to compete effectively in the production of goods as well as the provision of services.[1]

The toughest challenge is coming from the Far East. Japan has emerged as the world's premier industrial competitor, routinely achieving high quality and fast turnaround in manufacturing. Alone among advanced industrial countries, Japan managed in the 1980s to combine rapid productivity growth in manufacturing with rising manufacturing employment, rising wages and benefits, and greatly rising output. South Korea and Taiwan have taken giant steps along the road to manufacturing development, and while

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[1]U.S. Congress, Office of Technology Assessment, Paying the Bill: Manufacturing and America's Trade Deficit, OTA-ITE-390 (Washington, D.C.: U.S. Government Printing Office, 1988).

they are still far from achieving the levels of productivity and quality of American manufacturers in all industries, the results in the industries they have pursued most assiduously is impressive. Already, Korean and Taiwanese companies are major players in world markets for commodity semiconductors and personal computers, and they are diversifying fast. Europe has not stood still either. After a decade or more of talk of "Eurosclerosis," the Community has put together a plan to promote industrial competitiveness in a unified market and backed it with impressive political and resource commitments. The dazzling political developments in the East Bloc will obviously affect the pace and performance of the European Community, and it is too soon to tell how; nonetheless, it is clear that Europe has recognized the need for extraordinary action to bolster competitiveness. What has the United States been doing?

American manufacturers have recognized the need for improvement in quality and productivity, and many are making progress. It is not enough. Our ablest competitors are moving faster, and it will take cooperative efforts on the part of both manufacturers and government to keep up with those competitors. So far, the American government has given little more than lip service to improving manufacturing competitiveness. This sets it apart from Japan, Korea, and the European Community. Almost alone among developing or developed country governments, the United States government continues to profess the belief that market mechanisms alone can identify and adequately support promising industries or technologies, with no need for any government contribution. Government has intervened in a few cases where loss of competitiveness was acute. Congressional funding for Sematech, the consortium to develop advanced dymanic random access memory (DRAM) manufacturing technology, is probably the most prominent example. But while building civilian industrial competitiveness was clearly the objective of Sematech, it was still justified on the traditional ground of national security. Increasingly, however, those concerned about

meeting our national security needs and those concerned about civilian industrial competitiveness are finding a common set of concerns. It is now impossible to provide adequately for the nation's security without taking steps to improve the nation's civilian industrial performance as well.

There is no single solution, but all the signs point in one direction: America must improve technology in manufacturing, from product design to process development and refinement. While many of the necessary changes are up to manufacturers themselves, there is a great deal the government can do to facilitate technology development and diffusion. Our report identifies four broad policy areas for Congressional consideration.

The first we call strategic technology policy. In the past, the U.S. government has been reluctant to adopt anticipatory policies to build competitiveness. This reluctance was reinforced by the many examples of inefficient central planning, and the superiority of market-led development throughout most of the twentieth century. But in the last two or three decades, examples of successful government involvement with industrial development have become more common, and are fast becoming the norm among industrialized countries. Our ablest international competitors assuredly do not have freer markets or lighter government involvement in supporting industrial development, acquisition, and diffusion than the United States. This is not reason enough to plunge into a whole new set of policies, but, combined with the fact that our current policy has so manifestly failed to keep American manufacturers at the leading edge, it is a good reason to consider new approaches.

Strategic Technology Policy. One of those new approaches is to create a Federal institution, like a civilian DARPA (Defense Advanced Research Projects Agency) that can support selected technologies of great promise but high risk. The increasing complexity of technology, particularly in microelectronics, has significantly raised the ante for staying in many kinds of high-tech manufacturing. The costs of developing next-

generation products, constructing manufacturing facilities, and refining manufacturing processes now commonly run into the hundreds of millions and even billions of dollars, and require several years, so that few companies but the largest and most financially secure can afford the game. Even for those, keeping up with or ahead of the competition may involve bet-the-company investments. Especially in America's financial environment, which is less conducive to such investments than those of Japan or West Germany, some support from government could make an important difference.

There are several ways to do this institutionally. One bill authorized $100 million for the National Institute for Standards and Technology (NIST) to support industry-led joint R&D in economically critical technologies, five of which are spelled out in the Act. Another approach is to create a new Civilian Technology Agency, possibly with a new Department of Industry and Technology (taking the place of the Department of Commerce). The agency could make grants or cooperative agreements with private performers of research and developments on high-risk projects that could have exceptional value to the civilian economy.

The Civilian Technology Agency has been proposed before, and always provokes a debate over whether government can effectively "pick winners." There are numerous examples of foreign governments doing so, and America's own history provides instances of successful commercial industries building on abundant government support of technology. The Department of Defense's early support of the semiconductor and computer industries was key to their development, as was government support for civilian aircraft technology in the early part of this century. Agricultural technology development and diffusion has also been heavily supported by government for decades, through the land grant universities and the Agricultural Extension Service. In all these cases, it is fair to say both that government support was crucial to technology

development and that, on balance, the endeavor was successful. There have been failures too: one of the most often cited is that of the Synfuels Corporation, an ill-starred attempt to make petroleum substitutes from wood, coal, and oil shale.

We can learn a great deal from our own and foreign experience with supporting industrial technologies. From Synfuels, we take the lesson that picking promising solutions in an atmosphere of crisis is far more difficult than if it can be done on a thoughtful, premeditated basis. Another potential problem is parochialism. Many are concerned that a CTA would fall victim to special interests, and would become the focus of intense lobbying efforts that promote technologies not necessarily in the best interests of the nation. Care would have to be taken to design an agency that could work closely with industry to select and support promising technologies, yet not become the captive of all industry's wishes. Another requisite for such an agency would be that the projects it selected have substantial industry funding, to guarantee commitment. This cuts both ways: the agency would also have to be able to commit to fairly long-term funding once it selected a particular technology.

One of the surest ways to doom such an effort would be to subject the agency to unrealistic expectations. This is a departure in American culture, both business and government, where the failure to get returns rapidly is often interpreted as failure. If we decide to try the CTA approach, we must be prepared to give it enough time and enough resources to prove itself; this means giving it the leeway to make some mistakes, as well. Like the other approaches to restoring competitiveness outlined in the report, this one is experimental, and will require patience, some fine tuning, and commitment.

Encouraging Long Term Investment. Government's support for developing key new technologies, if done correctly, could help. We should not expect government involvement to replace market mechanisms in telling producers which investments make sense, or which industries are most appropriate for continued development. However,

the American financial climate is less supportive of investments in manufacturing--particularly long-term investments in R&D or plant and equipment, both needed to keep up with the competition--than those of Japan and West Germany, our strongest competitors. The principal reason is high U.S. capital costs.

The combination of massive Federal budget deficits (or dissaving, to use the economic term) and anemic personal and business saving is instrumental in keeping real interest rates high, which is an important factor driving up capital costs to business. For some kinds of investment--R&D, for example, or plant and equipment--American capital costs are often up to 50 percent higher than those of Japan and West Germany. This, in turn, discourages longer-term investment, and encourages managers to focus (disproportionately, in international comparison) on short-term returns.

Another part of the financial environment that discourages long-term investment in manufacturing has been the hostile takeover wave. The best defense against a hostile takeover is a high stock price, which in turn depends heavily on short-term profits. Overemphasizing near-term profit performance is generally not consistent with long-term investments in technology development or improvement. While the impact of mergers and acquisitions as a whole on R&D throughout the economy has been small to insignificant, the story is different for hostile takeovers (or defenses against them) in manufacturing, and it is also different in capital investment. Hostile takeovers and other forms of externally induced restructuring have resulted in reduced investment in R&D in manufacturing, and the general slowdown in R&D expenditure in manufacturing may be partly attributable to companies' financial maneuvering to avoid becoming takeover targets. Moreover, mergers and acquisitions are commonly associated with curtailed capital investment.

In short, the "now-nowism" that American managers are infamous for is, in part, a rational response to the U.S. financial environment. Government has many options for making the financial environment more conducive to long-term investment, particularly in

R&D and new plant and equipment. The most obvious--and probably the most important--is to make significant reductions in the federal budget deficit, with the purpose of eliminating it in a few years. Another important step is encouraging higher savings. Household savings rates fell to all-time lows in the mid 1980s, and while they have partially recovered since then, they are still below historic levels. Moreover, the case that our investment needs are greater than they were in the past is very strong, and greater investment call for higher than historic savings rates, not lower. Government could encourage household savings in several ways. One is to increases in regular savings through lower taxes on interest income earned on savings, or subsidized guaranteed interest rates on savings instruments. Another is a consumption tax, with appropriate exemptions to avoid penalizing low-income households. Limiting deductibility of mortgage interest could also encourage households to save in a form that encourages capital formation throughout the economy.

Business savings--in the form of retained earnings--are also low. The latter could be encouraged by reducing the need for businesses to pay out greater proportions of their earnings to equity holders--possibly by encouraging investors to hold their equities longer. This could also be a damper on takeover activity. Congress could encourage slower turnover of equities by implementing a steeply variable capital gains tax schedule, with very high taxation of gains held for a year or less (50 percent or more, according to some proposals), declining to a rate much lower than that on ordinary income for gains held for several years. To be effective at curtailing takeover activity, the capital gains tax would also have to be applied to institutional investors, who currently pay no capital gains tax. Another possibility is to tax securities transactions, which would penalize those whose turnover is heaviest (and therefore, those who hold securities for the shortest periods of time).

Finally, even if government is unable to take the steps that would lead to overall reduction in capital costs in the near future, there are ways to lower the costs of investment in specific activities most conducive to improved technology. Specifically, Congress could consider tax exemptions or deductions for investment in capital equipment and R&D, above those that already exist (the R&D tax credit, for example). Even with the R&D tax credit in place, the cost of capital for R&D is still significantly higher than that of Japan; and many of the tax breaks once accorded to capital investment have been eliminated.

Human Resources. Like capital costs, human resources have a pervasive effect on manufacturing. Managers have grumbled for years about the shortcomings of American public schools and the poorly educated work force, but the talk now is of a crisis. Young people leaving school with meager math and reading skills, and midcareer workers who have not brushed up their math and reading skills in years, are not prepared to deal with computer printouts and digital analyzers to monitor quality on the assembly line. Yet those are just the kind of skills manufacturing demands.

There is a broad consensus that the Nation's public school system needs help. Even if it arrived tomorrow, however, the results would be many years coming. A more immediate approach--though not a substitute for improved primary and secondary education--is to upgrade the skills of people already in the work force. Some large companies are providing education and training themselves, but smaller companies are often unable to; moreover, the financial burden even for large companies can be extensive. Government could help workers improve their skills in several ways. One is to offer additional federally guaranteed student loans to employed people taking classes outside work; another is to allow employers and employees to deduct costs of training and education (the present law allows this, but with some limitations). Training could also be made part of federally supported industrial extension services, a matter I shall go into later.

Engineers and other technically trained people (technicians and first-line supervisors, in particular) are becoming more and more valuable in manufacturing. Engineers, in particular, are a crucial element; yet the demographic pool from which they have traditionally come--white males--is shrinking. Though there is not now an obvious shortage of engineers, we could face one in the future unless women and minorities can be encouraged to enter engineering in greater numbers than they have in the past. This will depend heavily on progress in upgrading elementary and secondary arithmetic, math and science education. Other measures that could provide some relief while we improve the public school system are programs to retrain engineers who have been working in the military sector so they can enter civilian manufacturing, and broader programs to fund midcareer training for engineers already in manufacturing. Federal support of manufacturing engineering research and education could be strengthened, possibly through the creation of a Manufacturing Sciences Directorate in the National Science Foundation.

Diffusing Manufacturing Technology. Americans are accustomed to thinking of U.S. manufacturers as technology leaders, and indeed, some are. But many are not; in particular, many small and medium sized firms have difficulty keeping up with advances in manufacturing technology, and some are stuck in a technological backwater. Even for large firms there are some obstacles to technology diffusion and acquisition.

The most imposing of those obstacles, for many of America's 355,000 small and medium-sized firms, is the difficulty of acquiring competent technical knowledge and assistance. Large manufacturers transfer some technology to their smaller suppliers of necessity, and vendors and consultants also make a contribution. But these kinds of support do not come close, in either amount or character, to the broad, deep institutions in Japan and Germany that support technology diffusion to small and medium enterprises. The Federal government and some States have initiated programs to give

technical assistance and training to small firms, and there is room for considerable expansion. Together, Federal and State efforts to demonstrate technologies and transfer technical knowledge one-on-one to firms probably add up to a no more than $40 to $50 million a year. Japan spends tens of billions of dollars a year on combined technology extension and loans or loan guarantees that help manufacturers to implement the advice they get.

Congress could deepen its commitment to upgrading technology in small and medium sized manufacturing enterprises in several ways. Currently, Federal programs include (1) three existing and three more planned Manufacturing Technology Centers to demonstrate advanced technology and provide extension, (2) some assistance to State extension programs, and (3) the Advanced Technology Program, a mechanism for Federal guidance and participation in joint R&D ventures with private firms. Together, these three programs have funding of less than $19 million for fiscal year 1990. A smattering of other programs--the largest of which, Trade Adjustment Assistance, is funded at less than $10 million--provide some technical assistance, but the whole effort together is small in comparison to the need. Increased funding for either the Manufacturing Technology Centers and State industrial extension services, or both, could be considered. There are roles for both Federal and State programs, and both fulfill some needs that the other cannot. With the current paltry funding at all levels, there is considerable scope for expansion of all programs before serious possibilities for overlap or duplication arise.

Financial aid, in the form of loans or loan guarantees with subsidized interest rates, is a cornerstone of Japanese technical extension. Industrial extension may be useless to some small manufacturers unless there is also the possibility of some financial aid, because in some cases the recommendation is for things that cost money: new plant or equipment, new designs, training, and the like. While all businesses are

handicapped by high capital costs, small businesses have special financial problems; they must usually pay more for both debt and equity capital, and retained earnings may not be large or steady enough to rely on. Congress could encourage small firms to invest in advanced technology and the training needed to use it through loans or loan guarantees or a federally subsidized equipment leasing program. The latter could serve two purposes. The first is to make advanced equipment available to small businesses at subsidized rates, and the second, if it bought only U.S.-made equipment, is to provide a steady market to U.S. equipment producers.

Our report also discusses several other ways government might contribute to improved technology in manufacturing. Some of these options are to improve transfer of technology from Federal labs to industry, and to facilitate cooperation in R&D between industry and Federal labs; to make small modifications in antitrust law and enforcement to encourage R&D cooperation among firms; to enable manufacturers of all sizes to gain access to Japanese technology; and to provide better protection of intellectual property.

No single option proposed in OTA's report, taken by itself, will make a dramatic difference overnight. They need to be taken in combination and given a time for the effects to be seen. Even then, they might not go far enough to boost American manufacturing to world class level, because other nations are doing much more. However, one thing is sure: without some change in policy that provides greater support for manufacturers, U.S. manufacturing competitiveness will continue along the path of decline it is on now. Whether the United States should go beyond technology policy and employ more comprehensive strategies to bolster competitiveness is an open question, only touched on this report. Industry and trade policies of the Asian rim nations and the European Community, and their possible relevance to U.S. policy, will be considered in the final report of OTA's assessment of Technology, Innovation, and U.S. Trade.

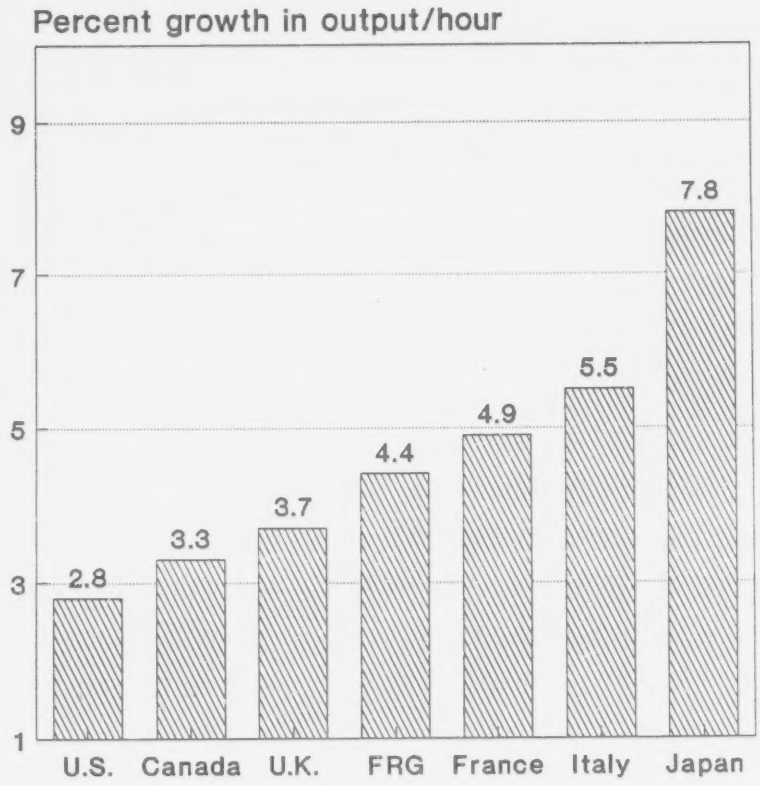
## What Government Can Do To Build U.S. Manufacturing Competitiveness

- *Improve the Financial Environment*
- *Upgrade Education and Training*
- *Diffuse Manufacturing Technology*
- *Support R&D for Commercially Important Technologies*

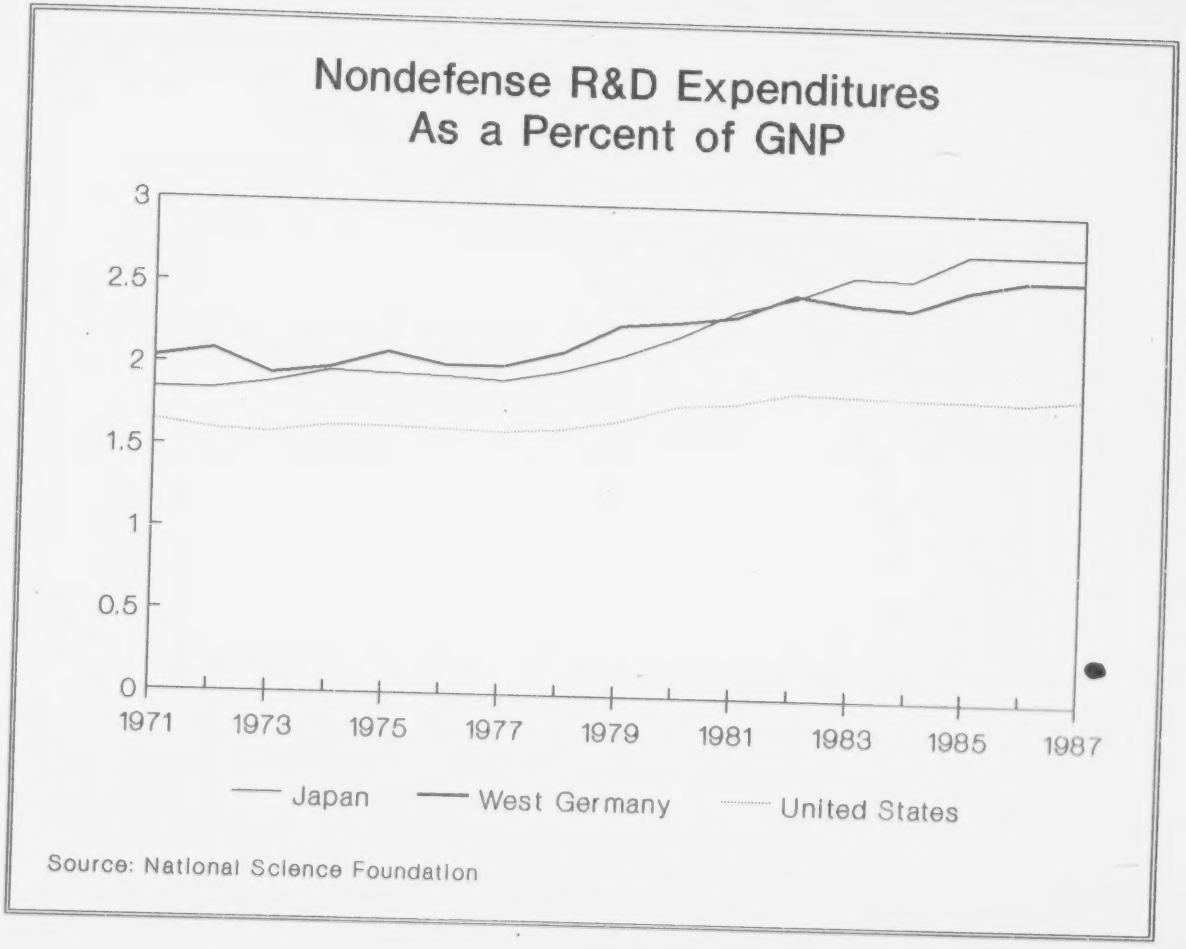
# Merchandise and Manufacturing Trade Balances, 1960-88

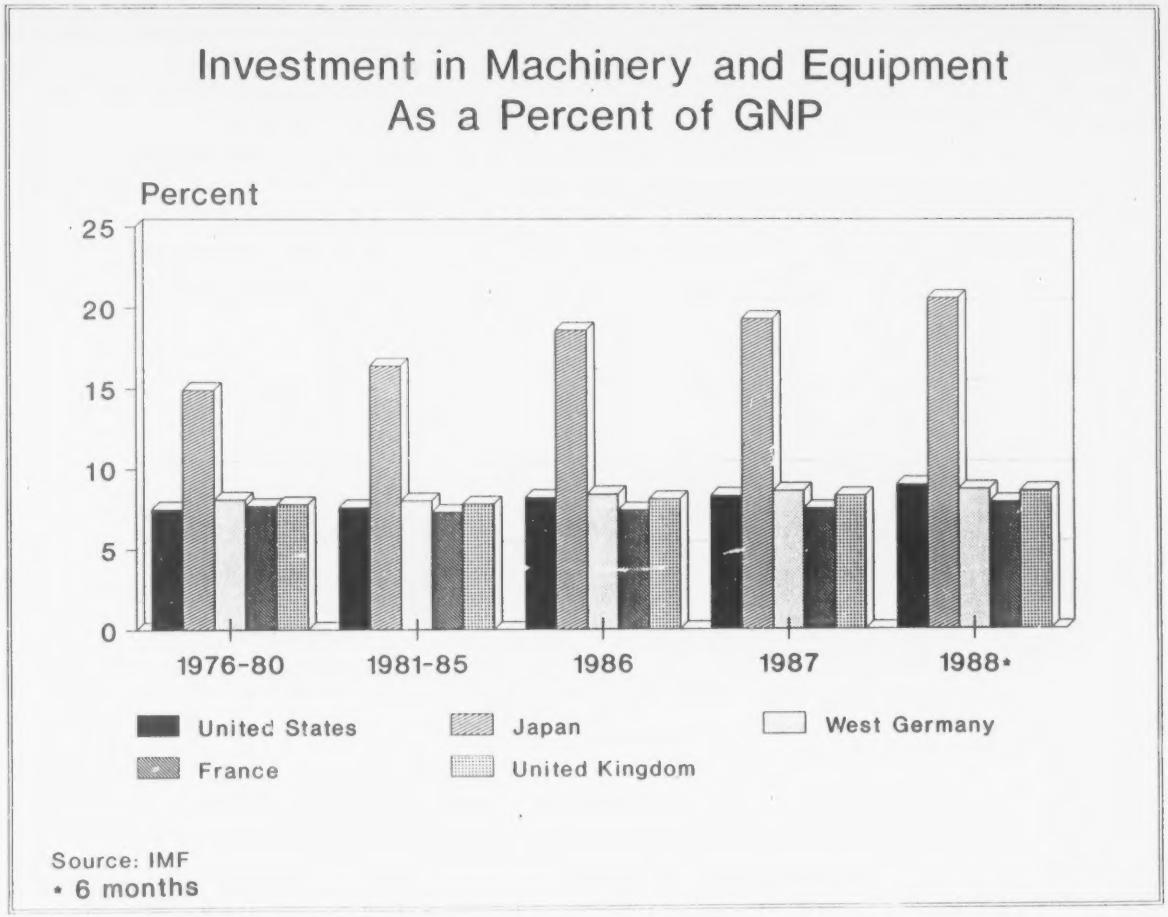
Source: U.S. Department of Commerce

## Average Annual Productivity Growth In Manufacturing, 1960-88

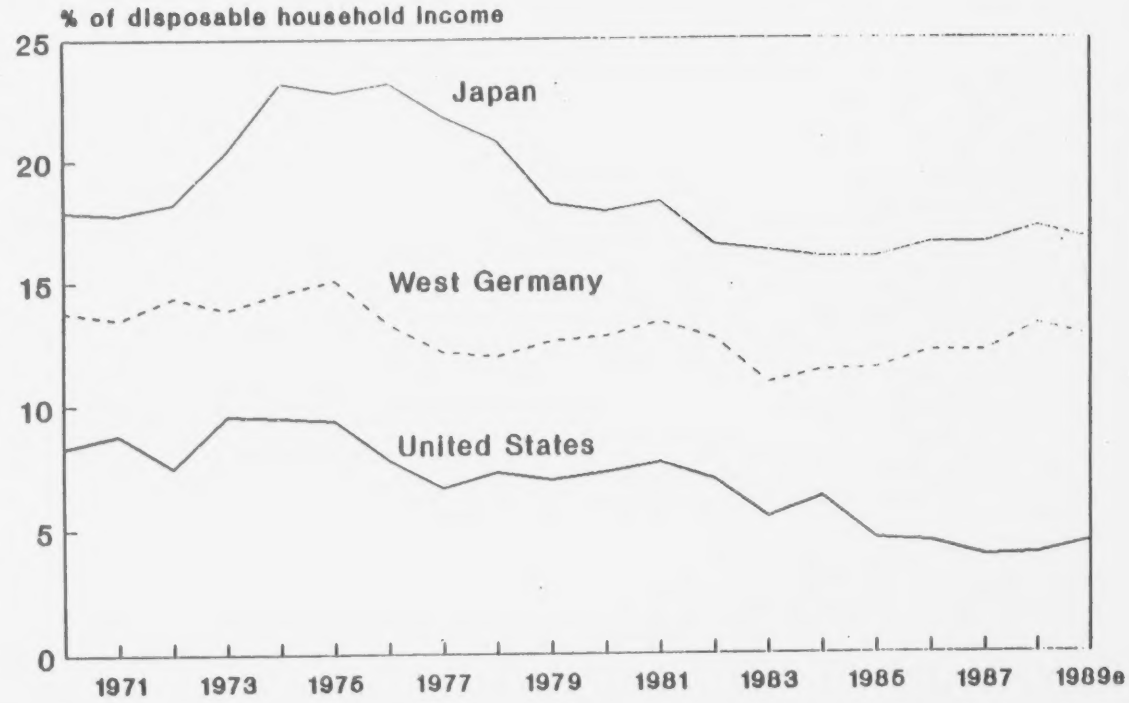



Source: Department of Labor


Nondefense R&D Expenditures
As a Percent of GNP
3
2.5
2
1.5
1
0.5
0
1971
1973
1975
1977
1979
1981
1983
1985
1987
Japan
West Germany
United States
Source: National Science Foundation

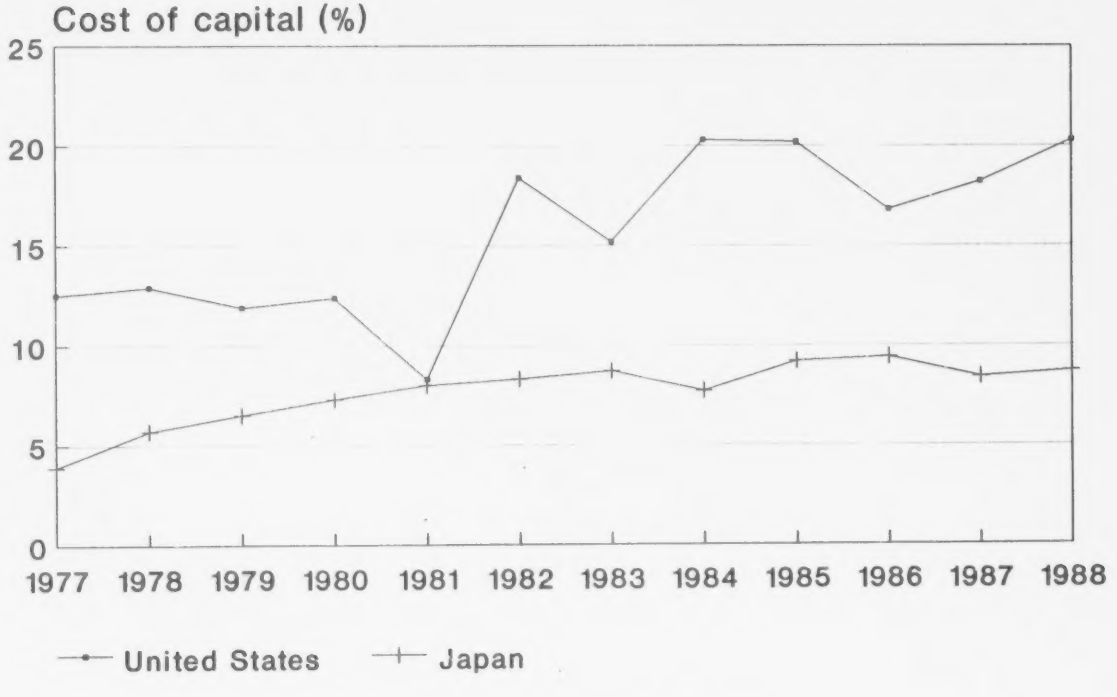

Investment in Machinery and Equipment
As a Percent of GNP
Percent
25
20
15
10
5
0
1976-80
1981-85
1986
1987
1988*
United States
Japan
West Germany
France
United Kingdom
Source: IMF
* 6 months

# Net Household Savings



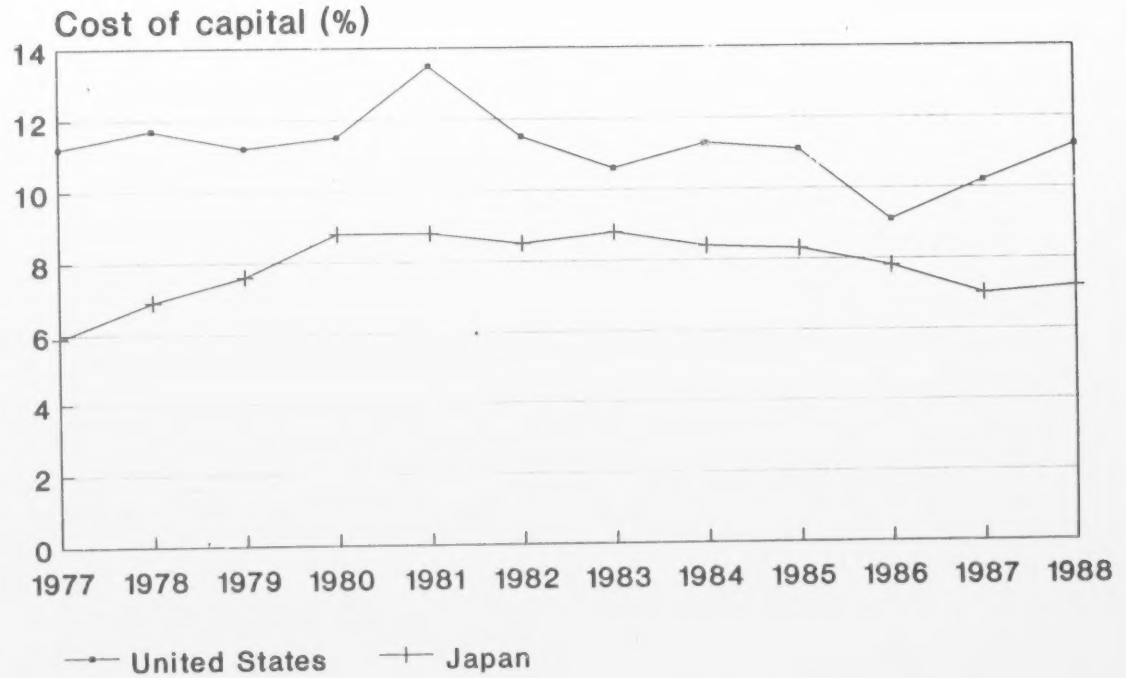

Source: OECD Economic Outlook, 12/88 Data for 1988 and 1989 are OECD estimates

# Cost of Capital for R&D Project With 10-Year Payoff Lag



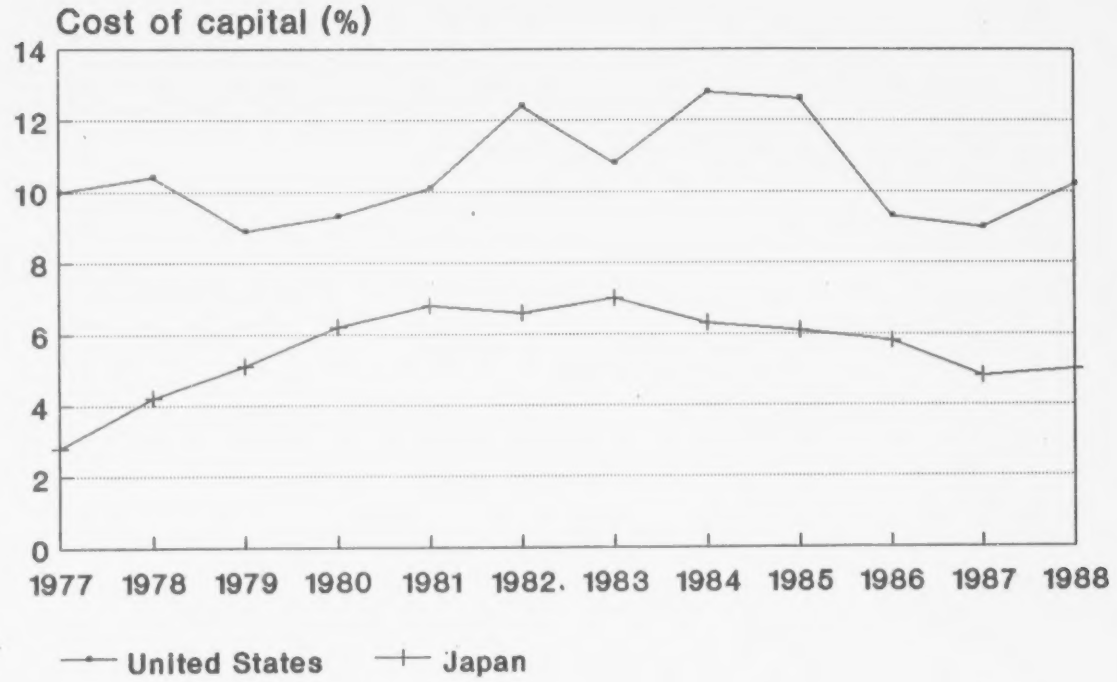

Source: Federal Reserve Bank of New York

# Cost of Capital for Equipment and Machinery with 20-Year Physical Life

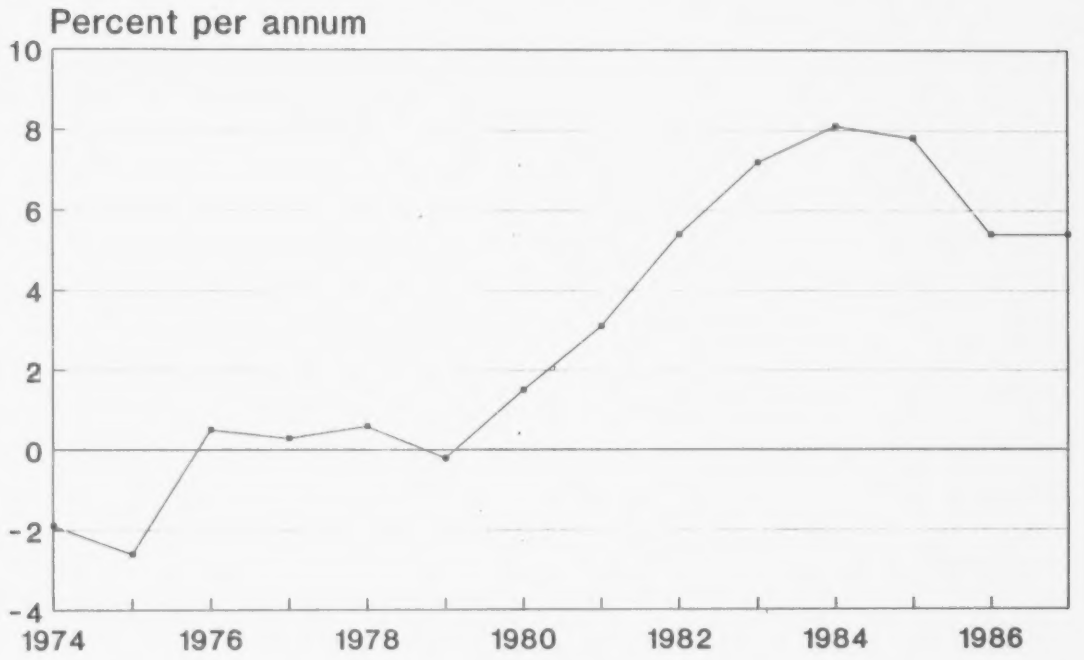



Source: Federal Reserve Bank of New York

# Cost of Capital for Factory With 40-Year Physicai Life

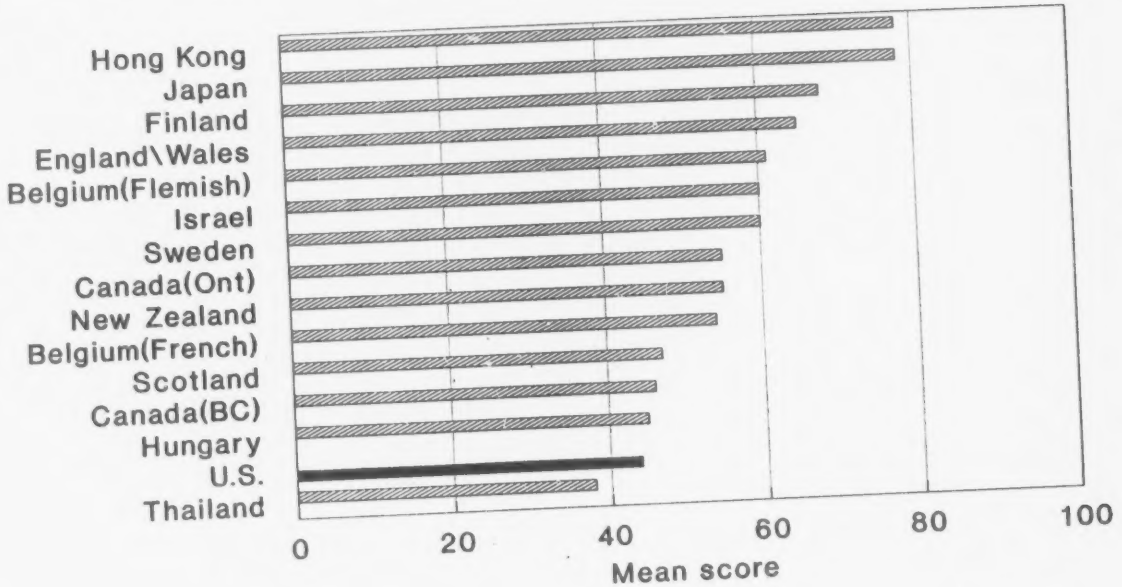


# Real Long-Term Interest Rates



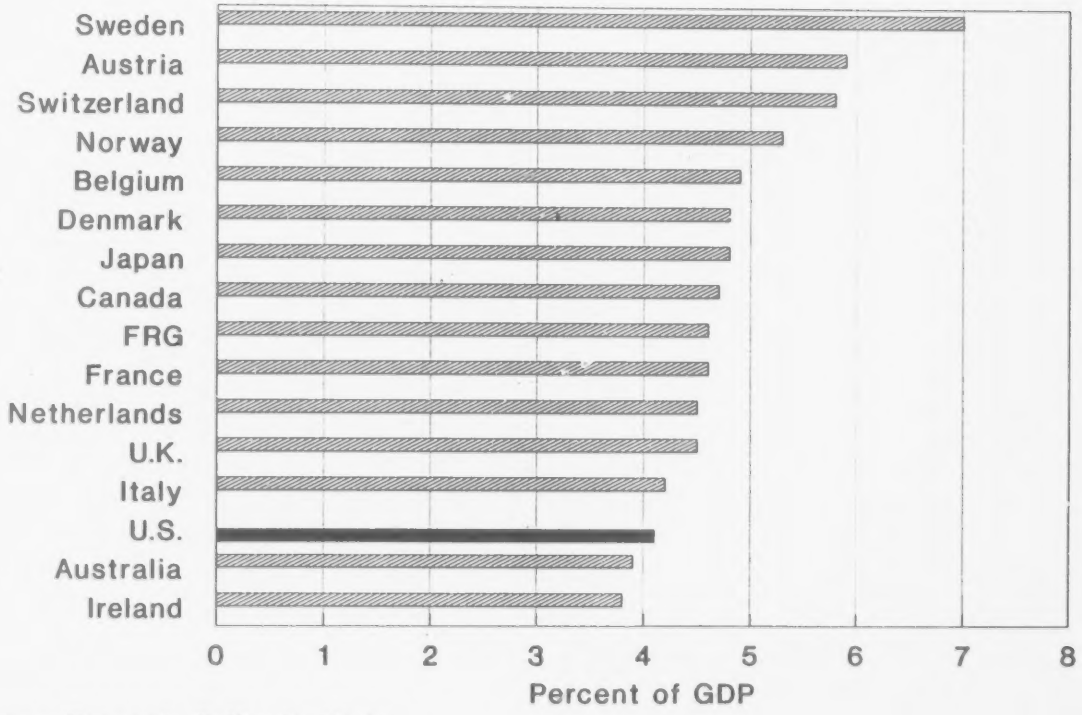

Source: OECD

# Twelfth Grade Achievement Scores in Advanced Algebra



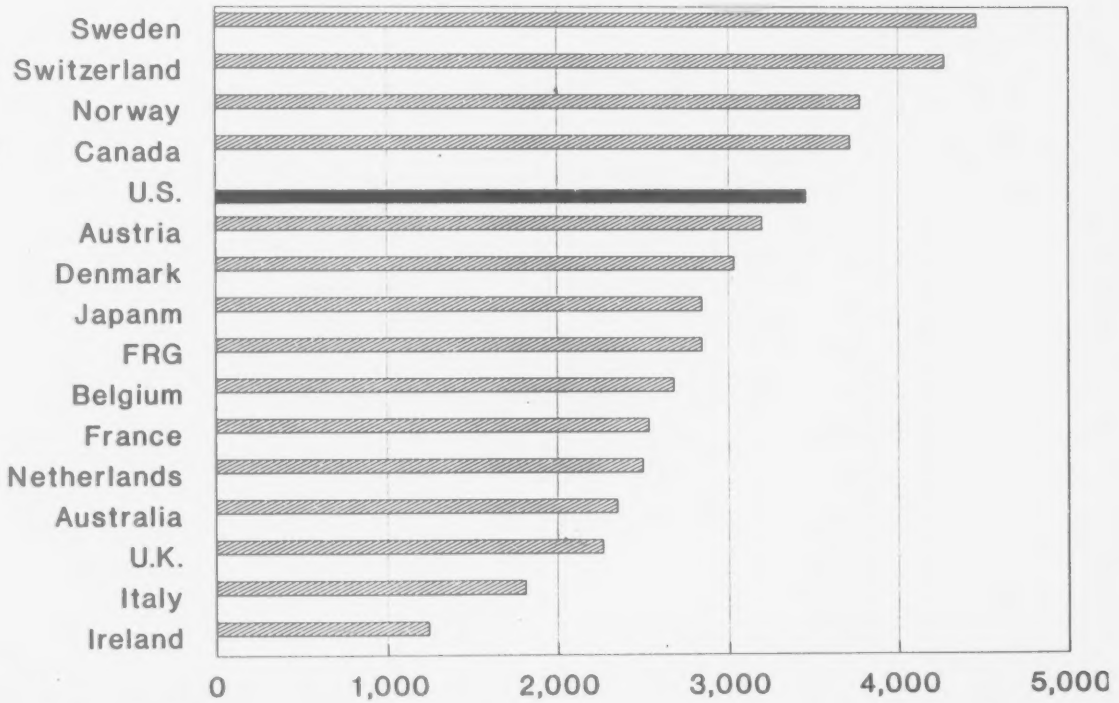

Source: International Association for Evaluation of Educational Achievement

# Spending for Education Grades K-12, Percent of GDP, 1985




Source: Economic Policy Institute

## Spending for Education Grades K-12, Per Pupil, 1985




Source: Economic Policy Institute

SUMMARY

# MAKING THINGS BETTER

## Competing in Manufacturing

CONGRESS OF THE UNITED STATES
OFFICE OF TECHNOLOGY ASSESSMENT

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# Foreword

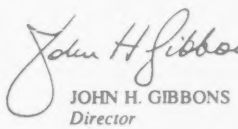
U.S. manufacturing is in trouble. That spells trouble for the Nation, because manufacturing provides well-paid jobs, pays for most privately funded research and development, and dominates international trade. In industry after industry, U.S. manufacturers have lost out to competitors who are able to make things better—products with better features and more reliable quality, at lower cost. The key to this better performance is technology, which includes not only new products and advanced manufacturing equipment but also efficient organization of work and effective use of people. Once, U.S. manufacturers led the world in technology. Now, in one field after another—first radios and TV, then automobiles, now semiconductors—Japanese manufacturers are passing us by. Other Asian countries like Korea and Taiwan are coming up fast, and Europe is mounting new challenges.

In a sense, these changes are welcome. Since World War II, U.S. policy has aimed to strengthen the economies of advanced nations and help poorer ones develop, so it should be no surprise that the world is now full of able manufacturers. It was not part of the plan for the United States to fall to second rank, but that is what is happening.

This report considers ways to promote the restoration of American leadership in manufacturing technology. Some of the things that most need doing are up to industry—especially in handling people, from managers to engineers to shopfloor workers, and in forming stable, productive relationships between different segments of an industry complex. Government also has a critical role to play. The first essential is to create an economic environment that supports manufacturing and encourages long-term investment in technology. This means higher national savings rates and a declining Federal deficit. Other less traditional activities (at least for the U.S. Government) also deserve consideration—for example, collaboration with industry on supporting R&D for strategic technologies.

For many years, national security was almost the only acceptable reason for government support of commercial technologies and industrial excellence, but as the Cold War winds down, this reason becomes less compelling. In an era of more secure peace but tougher economic competition, national security is taking on new meanings. To preserve our long tradition of industrial success and rising living standards requires continuing innovation and successful adaptation of existing technology, and that is a task for industry, government, and American citizens.

This report is the second in a series of three in OTA's assessment of Technology, Innovation, and U.S. Trade. The assessment was requested by the Senate Committee on Finance; the Senate Committee on Banking, Housing and Urban Affairs; and the House Committee on Banking, Finance and Urban Affairs. The first report in the series, *Paying the Bill: Manufacturing and America's Trade Deficit*, concluded that the stubbornly high U.S. trade deficits of the 1980s and many other signs pointed to genuine weakness in American manufacturing and lags in technology, compared to our best competitors. This report looks for some of the reasons for the weakness, and suggests policies aimed specifically at repairing it. The last report will examine the trade and industrial policies of Japan, other East Asian countries, and Europe; and their possible relevance to the competitive position of the United States.



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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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# Summary

American manufacturing has never been in more trouble than it is now. Its biggest challenge is from Japan, where, more than in any other nation, well-designed products are manufactured with great reliability, while costs are rigorously controlled. Other nations, developed and developing, are rising to the Japanese challenge in creative ways. The important difference is that many of those nations are responding *as nations*, with the support and participation of government. While some American companies and institutions have redoubled efforts to improve manufacturing, the government is dozing at the switch. Certainly, there are many problems that manufacturers must solve themselves. But some of the problems are generated by the American people and government. As a nation, we owe it to ourselves to help with their solution.

Symptoms of America's problems are clearly visible: the merchandise trade deficit remains stubbornly high, despite significant downward adjustment of the dollar against major currencies (figure 1). Productivity growth is sluggish compared with that of many other advanced and developing nations, including our ablest competitors (figure 2). U.S. manufacturers are increasingly dependent on foreign producers for a wide range of machinery and tools of production. Even the microelectronics industry, once the standard bearer for American competence and inventiveness, is losing sales and market share to Japanese, Korean, and Taiwanese producers.

**Figure 1—Merchandise Trade Balance**

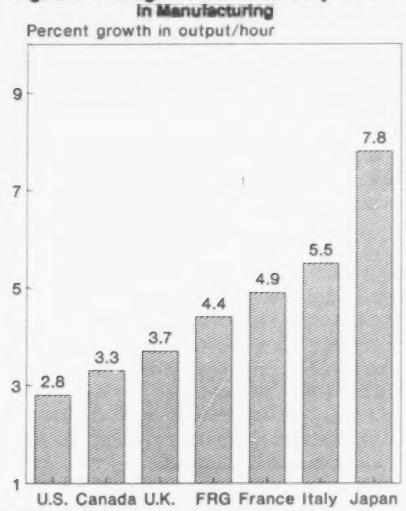
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, *Business Conditions Digest, September 1989* (Washington, DC: U.S. Government Printing Office, September 1989), table 622.

The weaknesses in U.S. manufacturing technology must be cured if the Nation is to enjoy rising living standards together with a strong, stable position in international trade. Most of the U.S. trade deficit is in manufactured goods (figure 3). The most constructive way to right the deficit is to manufacture products that the world will buy because the products are well-made and reasonably priced (not just because a low dollar makes them cheap). More fundamentally, manufacturing is valuable to the Nation as a direct source of productive, well-paid jobs and the indirect source of many better-than-average jobs in the service sector (table 1). Manufacturing also supports most of this country's commercial research and development.[1]

There is no single solution, but all the signs point in one direction: U.S. manufacturing technology must improve—in everything from product design to manufacturing process development and refinement. For industrial nations, technology is the key to competitive success. Nations that rely on low wages to sell their goods in the world market are, by definition, poor, whereas superior technology raises productivity and thus supports rising standards of living. Moreover, technology is a steady, predictable source of advantage, while others may shift with political currents. For example, a nation's fiscal and monetary policies affect the value of its currency, which in turn affects the salability of its manufactured goods in the world market. But macroeconomic policies are change-

[1]For more detailed discussion of the place of manufacturing in international trade and the national economy, see Office of Technology Assessment, *Paying the Bill: Manufacturing and America's Trade Deficit*, OTA-ITE-390 (Springfield, VA: National Technical Information Service, 1988).

**Figure 2—Average Annual Productivity Growth in Manufacturing**




SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Labor Trends, 1988," June 1989, table 1.

**Figure 3—Merchandise and Manufacturing Trade Balances, 1960-88**

SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, *Business Conditions Digest, September 1989* (Washington, DC: U.S. Government Printing Office, September 1989), table 622; U.S. Department of Commerce, International Trade Administration, Office of Trade and Information Analysis, unpublished data, 1989; and President of the United States and the Council of Economic Advisers, *Economic Report of the President* (Washington, DC: U.S. Government Printing Office, January 1987), table B-102.

able, and are far beyond the control of private firms.

Americans are used to thinking of their nation as leading the world in technology—with the select company perhaps of a few other developed countries or a few foreign industries. But the realization has dawned that we are no longer at the forefront.[2] Several major U.S. industries have not only fallen behind in technology, but will be hard put to catch up even if they adopt a whole catalog of changes needed to reverse the slide. Not all American industries are lagging, but trends in many sectors, from computers to aircraft, indicate that our ablest competitors can now or soon will match our technology, and are accelerating faster.

Is this a problem? We have long accepted (in principle, if not in fact) that our technological lead across a wide range of industries was fated to narrow or disappear as developed countries recovered from war damage and poorer countries advanced. But we did not expect the gap to close so rapidly, and we certainly never expected to fall behind.

The toughest challenge is coming from the Far East. At the close of the 1980s, Japan has emerged as the world's premier industrial competitor. The United States is still the richest of nations, with gross domestic product per capita considerably higher than most others (only Canada is close; see figure 4). Several European countries are strong performers in one or another manufacturing sector or product—especially Germany, which excels in metalworking and machinery, and consistently runs large trade surpluses. But Japan's record is unique. It has led all major industrial countries in productivity growth for decades—not just in the early postwar years when it was rising from the ashes, but also right through the 1970s and 1980s, despite the oil shocks and two periods of a steeply rising yen. Alone among advanced industrial countries, Japan managed in the 1980s to combine great productivity growth in manu-

[2]For aggregate indicators of America's relative technological performance, ibid., pp. 26-35.

**Table 1—Work Force Involved in Manufacturing and Average Full-Time Equivalent Compensation, 1984**

| | Wage and salary workers involved in manufacturing | Percent of sector employment involved in manufacturing | Average annual full-time equivalent compensation (thousands of dollars) |
|---|---|---|---|
| Agriculture | 792 | 50.4% | $11.3 |
| Mining | 443 | 45.5 | 37.0 |
| Construction | 575 | 13.3 | 26.8 |
| Manufacturing | 19,396 | 100.0 | 28.7 |
| All public and private services | 6,492 | 9.4 | 24.6 |
| All private services | 6,343 | 11.9 | 24.4 |
| Wholesale trade | 1,501 | 26.3 | 27.6 |
| Transportation and warehousing | 704 | 24.2 | 30.3 |
| Business services | 1,276 | 22.8 | 24.7 |
| Radio and TV broadcasting | 50 | 21.8 | 29.6 |
| Electric, gas, water and sanitary services | 171 | 21.4 | 37.5 |
| Communications, except radio and television | 129 | 11.6 | 39.7 |
| Automobile repair and services | 79 | 11.6 | 17.8 |
| Retail, except eating and drinking | 1,176 | 10.3 | 17.1 |
| Finance and insurance | 413 | 9.0 | 27.4 |
| Hotels, personal and repair services (exc. auto) | 207 | 8.5 | 15.7 |
| Eating and drinking places | 428 | 7.9 | 11.0 |
| Real estate and rental* | 72 | 6.7 | 21.1 |
| Amusements | 46 | 4.5 | 19.9 |
| Health, educ. & social serv. and nonprofit org. | 89 | 0.9 | 20.2 |
| Government | 149 | 0.9 | 31.1 |
| Total | 27,697 | 29.0% | $27.4 |

SOURCE: Workers involved in manufacturing data is derived from OTA Input-Output Model (1980 technical coefficients, 1984 estimated demand, 1984 BLS employment, adjusted for capital flows, imports and duties). Compensation data derived from Bureau of Economic Analysis, National Income and Product Accounts, electronic data, mapped to input-output industry classifications.

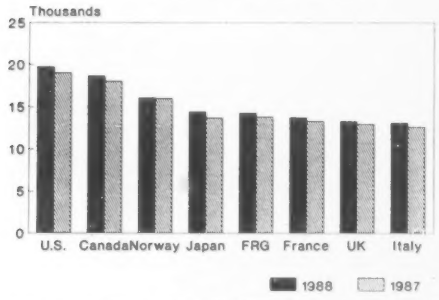
facturing with rising manufacturing employment, rising wages and benefits, and greatly rising output.

These singular achievements suggest some systematic advantages in Japan that are well worth examining. There are of course elements of superiority in other countries too (including the United States) and things to be learned from them. But Japan's sustained improvement in productivity and its pre-eminence in several industries that were once nearly an American preserve (e.g., computers, semiconductors) make Japanese manufacturing a subject of special interest. Thus this assessment on the contribution technology makes to competitiveness in manufacturing concentrates quite heavily—though not exclusively—on Japan.

The Japanese accomplishment rests to a great extent on technology. Broadly defined, manufacturing technology covers not only the generation of new products but also know-how in using equipment, organizing work, and managing people to make the products. Where U.S. firms have fallen down in recent years is in the manufacturing process. The American system, including our great universities as well as industrial labs, still excels at making technical discoveries and inventing new products. But foreign companies (especially Japanese companies) have repeatedly beaten U.S. firms in getting new, improved versions of a great many products to market while keeping costs competitive and quality high.

Over the past decade or so, we have learned much about the sources of the Japanese manu-

**Figure 4—GDP Per Capita in 1988 U.S. Dollars (Purchasing Power Parity Exchange Rates)**




SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Productivity and Technology, unpublished data, August 1989.

facturing superiority. We have become familiar with features such as *kaizen*, or continual improvement in every detail of manufacturing; the training of workers to participate in *kaizen*, learn multiple skills, and work in teams; and *kanban*, the just-in-time delivery system for parts that depends on reliable high quality and reveals failures to achieve it. These features are all part of the "lean" production system that is practiced by the leading Japanese manufacturers and is widely credited with keeping costs low and quality high. The "buffered" system, common in U.S. plants, depends on having large stocks of parts and work in progress, so that faulty items can be replaced, and sizable repair areas for fixing up defects in the finished product.[3] The lean system, by contrast, is designed to expose problems while the work is in process, solve the problems, and from there on do it right the first time. If this report gives only passing attention to some of these aspects of Japanese manufacturing, that is not because they lack importance, but because they are very well-known.

Greater investment in advanced equipment is another advantage of leading Japanese industries. From 1976 through 1987, Japanese investment in machinery and equipment consistently ran from 14.9 to 20.6 percent of GNP; in America, it ranged from 7.5 to 9.0 percent of GNP[4] (figure 5). Japanese capital investment in the late 1980s was especially high, posting double-digit increases in both 1988 and 1989. In manufacturing, the rate of increase was even greater—over 25 percent for both years. An important reason for these whopping investment increases was a shift in production to higher value added goods.[5] Capital investment in American manufacturing rose only 9 percent from 1988 to 1989 (less in real terms).

It is not simply advanced hardware that gives Japanese manufacturers the edge, however. Their genius lies at least as much in the employment of people in relation to the hardware. This effective use of people is also a factor in the Japanese ability to shorten the product development cycle—to repeatedly incorporate state-of-the-art improvements in their products and bring them to market quickly. For example, it takes Japanese auto companies about 3 1/2 years to get a new model from design to full-scale production, compared to over 5 years for American and European auto makers.[6] A key difference is the Japanese emphasis on simultaneous rather than sequential engineering. The people doing research, development and design of the new model are in constant communication with the people responsible for manufacture. Other factors are involved too, such as the reliance of the major manufacturers on a trusted group of suppliers to do part of the product development work. The result is a headstart over slower competitors in responding to consumer

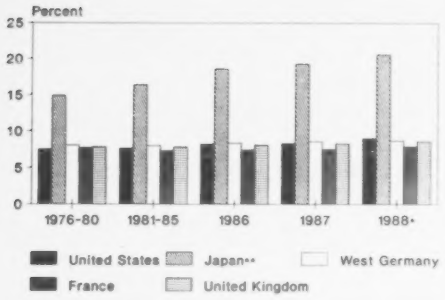
[3]These terms were coined by John F. Krafcik, "A New Diet for U.S. Manufacturing," *Technology Review*, Jan. 28, 1989.

[4]International Monetary Fund, *World Economic Outlook*, April 1989. The Japanese figures exclude public investment, while those for the United States do not.

[5]The Japan Development Bank, "The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Year 1988 to 1990," Economic and Industrial Research Department, September 1989.

[6]Kim B. Clark and Takahiro Fujimoto, "Overlapping Problem Solving in Product Development," working paper 87-048, Harvard Business School, revised April 1988.

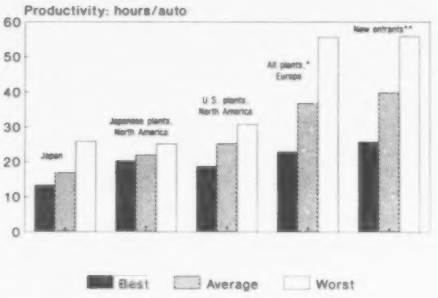
**Figure 5—Fixed Investment in Machinery and Equipment as a Percentage of GNP/GDP**




* January to June
** Figures for Japan exclude public investment.

SOURCE: International Monetary Fund (IMF), *World Economic Outlook* (Washington, DC: April 1989), table 17.

**Figure 6—Productivity Performance, World Auto Manufacturers**




* Includes foreign owned.
** Includes East Asia, Mexico, and Brazil.

SOURCE: John F. Krafcik and John Paul MacDuffie, "Explaining High Performance Manufacturing: The International Automotive Assembly Plant Study," paper prepared for the International Motor Vehicles Program International Policy Forum, May 1989.

preferences and, perhaps even more important, in incorporating the latest technologies.

Some American managers are now adopting Japanese-style approaches, or versions of them, to turn out better goods at lower cost. For example, in the early 1980s, it took twice as many hours to assemble a standard car in an average American auto plant as in the average Japanese plant. By 1988, U.S. assembly plants had improved enough that the Japanese advantage was down from 100 percent to about 50 percent (25.1 hours for assembly in the average U.S.-owned and managed plant v. 16.8 hours in the Japanese). The best Japanese plant had an advantage of 5.4 hours over the best American plant[7] (figure 6).

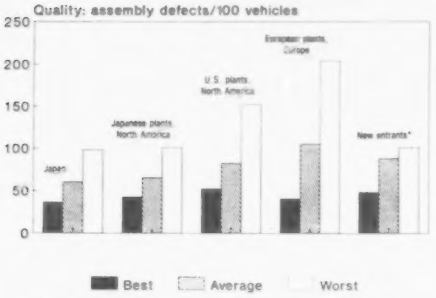
In quite a few other industries (e.g., textiles and steel), well-managed U.S. firms have shown that they are able to turn some of the Japanese-style approaches to good account. But that is no reason for complacency. For one thing, the target is moving. Faced with the high yen, which raises the prices of goods they export, the Japanese Government and Japanese manufacturers redoubled their own efforts to improve technology and competitiveness. For example, the best Japanese plant shaved assembly time for a standard model car from 16 to 13.2 hours in just one year, 1987 to 1988, and the average plant improved from 19.1 hours to 16.8.[8] The Japanese were also holding on to a lead in better quality. In 1988, the average Japanese assembly plant was turning out cars with less than three-quarters of the defects of cars produced in American plants. U.S. plants stacked up very well against the Europeans, however, as shown in figures 6 and 7.

The reasons for Japanese success are broad and complex. Public as well as private actions, and the interrelation between them, are very much involved. The issues selected for analysis in this assessment include both, and may be grouped into a few broad areas: 1) the cost and availability of capital, and its influence on business decisions to invest for the long pull in product and process improvements; 2) the use of human resources to contribute to manufacturing

[7]John F. Krafcik and John Paul Mac Duffie, "Explaining High Performance Manufacturing: The International Automotive Assembly Plant Study," working paper of the International Motor Vehicles Program of the Massachusetts Institute of Technology, May 1989.

[8]Ibid., p. 5.

**Figure 7—Quality Performance, World Auto Manufacturers**




* Includes East Asia, Mexico, and Brazil
NOTE: Data are derived from 1988 J.D. Powers International Quality Survey and corporate data.
SOURCE: John F. Krafcik and John Paul MacDuffie, "Explaining High Performance Manufacturing: The International Automotive Assembly Plant Study," paper prepared for the International Motor Vehicles Program International Policy Forum, May 1989.

excellence, with special emphasis on engineers; 3) relations between supplier and customer firms within an industry complex, in particular the benefits of close, cooperative links; 4) ways to diffuse new technologies from outside sources to private companies, and especially to smaller manufacturers; and 5) existing government programs—Federal, State, regional and local—that help (or in some cases hinder) U.S. manufacturing firms in using technology to improve their competitive performance.

Lessons from the successes of other countries are not always easy to apply. Some elements in the Japanese system may be quite adaptable to U.S. companies that are enterprising enough to try them—for example, close relations between different segments of an industry complex (e.g., chemical companies that make textile fibers, textile producers, apparel makers, designers, and retailers) in which suppliers are attuned and responsive to the needs of their customer firms, and purchasers are willing to form stable, cooperative relations with their suppliers. Other practices and policies of foreign nations would be much harder to translate into American terms—for example, the century-old system of vocational education that trains half the young people of West Germany in good work habits and a variety of skills. And some policies of other nations are quite foreign to our traditions and outlook—for example, centralized direction of trade and industrial policy as practiced in Korea (until recently, when controls have loosened somewhat).

One way or another, however, the United States must regain excellence in the manufacturing process. That is key to raising income for the Nation. No longer can U.S. industries count on profiting from new inventions for years before competitors begin to produce them. Many technical inventions cannot be protected from skillful imitators—and the world is now full of manufacturers who can quickly and ably produce things that were invented elsewhere (just as U.S. manufacturers themselves have often done with foreign inventions). Over the long run, a country and its citizens cannot control or profit from what they cannot produce competently.

Restoring or creating excellence is no easy task. U.S. manufacturers who once were the masters of mass-production grew complacent in the years of American domination. Many still cling to wasteful production systems that take a narrow view of cost reduction, and do it at the expense of reliability, flexibility, and customer service. Many smaller manufacturers are far behind the times technologically. Federal technology policy is still aimed much more at research and the generation of new inventions than at quickly diffusing new technologies (whatever their source) and putting them into practice. Some government policies run counter to manufacturers' efforts to improve their performance, although that is not their intention. Most important is the government's inability to eliminate the budget deficit, which increases pressure to raise interest rates and the value of the dollar, and directly diminishes manufacturers' ability to sustain long-term, risky investments. The Federal Government, along with many State and local governments, has initiated some new programs to help manufacturers improve competitiveness and technology, but these are modest at best. The dampening effects of macro-

economic and foreign policies can easily overwhelm them.

With will and effort, a nation's industries can change. Forty years ago, Japan was a poor nation, backward in manufacturing technology, lacking engineers and scientists, relying mostly on low labor costs to make products attractive enough for export. Between that Japan and the Japan we know today are years of heavy investment in people, technology, and machinery, and a great deal of sacrifice on the part of consumers. The United States today is in a far stronger position than Japan was then but, ironically, this may make it harder to undertake the sacrifices and changes needed to rebuild our competitiveness. We are still a wealthy nation, and there is no widespread feeling that we are in or approaching a crisis. Under such circumstances, it would take extraordinary leadership to summon the energies to make significant changes. One hopeful sign is that the nations of the European Community—also wealthy and with no apparent crisis—have pulled together to create a new economic order, with the Single Market Act.

The European Community's efforts to harmonize internal markets beginning in 1992 have several things in common with the measures Japan took to industrialize two decades ago. They also have much in common with measures the United States needs to consider to improve our competitive performance. Broadly speaking, they are measures to promote investment in people, technology, and equipment; to disseminate information and know-how; and to encourage cooperative efforts to solve common problems.

## INVESTMENT

Investments in technology require patience. Researchers, inventors, and designers often must wait years—sometimes decades—for their efforts to pay off. Although investments in equipment are more predictable and less risky, even these may not break even for years.

America's financial climate is not conducive to long-term investments in technology and equipment, compared with Japan, Germany, and the most rapidly developing Asian nations. Several things contribute to this relatively unfriendly environment. High U.S. capital costs shorten the time horizons of investors, so do the pressures exerted on companies by the stock market, particularly by institutional investors and takeover specialists. In sum, both government policies and business practices reinforce an excessive concern with short-term profit in America. If these conditions persist, it will be increasingly difficult to keep up with technological advances made elsewhere.

U.S. capital costs have been and remain high compared with those in Japan, the nation that provides the greatest contrast with U.S. short-term thinking. There is some disagreement over just how large (or small) the differences are, but most recent studies estimate significantly higher capital costs in the United States[9] (figures 8, 9, and 10). On the high side, the estimates range up to 13 percentage points difference, while the difference at the low end is on the order of 1 or 2 percentage points. Even relatively modest differences of a few percentage points in capital costs can be a significant disadvantage in making investments that take many years to pay off.

U.S. capital costs are high for many reasons. Interest rates rose in the 1980s and remain high principally because of the enormous pressure of the budget deficit, which is a large drain on savings, and the fall in other savings rates. But there is a great deal more to capital costs than interest rates. The price a firm pays for capital is also a function of its relationships with creditors and equity holders, and the taxes it pays. During Japan's high growth period, which lasted until 1973-74, heavy reliance on debt financing from main banks kept capital costs down for Japanese

[9]Michael L. Dertouzos, Richard K. Lester, and Robert M. Solow, *Made in America: Regaining the Productive Edge* (Cambridge, MA: The MIT Press, 1989).

**Figure 8—Cost of Capital for Equipment and Machinery With 20-Year Physical Life**

SOURCE: Robert N. McCauley and Steven A. Zimmer, "Explaining International Differences in the Cost of Capital," *Federal Reserve Bank of New York Quarterly Review*, Summer 1989, table 2.

**Figure 9—Cost of Capital for R&D Project With 10-Year Payoff Lag**

SOURCE: Robert N. McCauley and Steven A. Zimmer, "Explaining International Differences in the Cost of Capital," *Federal Reserve Bank of New York Quarterly Review*, Summer 1989, table 2.

manufacturing firms (particularly in favored industries). A variety of Japanese Government policies encouraged the banks to lend heavily at low rates to large corporations. These policies included direct government lending through the Japan Development Bank (which is a signal to private banks), administrative guidance from the Ministry of Finance, and close regulation of

**Figure 10—Cost of Capital for Factory With 40-Year Physical Life**

SOURCE: Robert N. McCauley and Steven A. Zimmer, "Explaining International Differences in the Cost of Capital," *Federal Reserve Bank of New York Quarterly Review*, Summer 1989, table 2.

every aspect of banking and finance, including the disposition of household savings.

Today, Japan has enormous capital reserves, and most major corporations finance all their investment with retained earnings and depreciation. Moreover, Japan is deregulating its financial markets, and large Japanese companies are getting more of their external capital in foreign markets. Most estimates of U.S. and Japanese capital costs still show American firms at a substantial disadvantage—one study, for instance, reports U.S. cost of capital at 20.3 percent, compared with 8.7 percent in Japan.[10] But even if nominal costs were the same, differences in the financial environments in the two countries would still favor Japanese firms. Most of the stock of large Japanese corporations is held by other corporations, often in the same *keiretsu* (industry group), who agree to hold the stock for long periods with few demands in return. This system, known variously as cross shareholding, mutual shareholding, or stable shareholding, is in marked contrast with U.S. practice. Here, shareholders must be given far more attention; corporations pay larger dividends, and corporate managers are under heavy

[10]Robert N. McCauley and Steven A. Zimmer, "Explaining International Differences in the Cost of Capital," *Federal Reserve Bank of New York Quarterly Review*, summer 1989, pp. 7-28. These figures apply to investments in research and development. Other investments, such as equipment and machinery and factories, are also shown to be more expensive in America than in Japan and West Germany.

pressure to show a profit each quarter. In the 1980s, new financial instruments have made it much easier for outsiders to mount takeover bids, and managers in U.S. companies feel that they must show profits or become vulnerable to takeover attempts. American managers' increasing preoccupation with the short-term bottom line in the 1980s is in part due to that vulnerability.

Several other factors tend to reinforce short-term bias in America. None by itself is conclusively important, but together they have a considerable effect. Company size and structure may account for some of the short term focus of the semiconductor industry, in particular. The leading Japanese semiconductor producers are large, integrated, stable companies making a variety of products, from semiconductors to computers and consumer goods. The U.S. industry has a few large, integrated producers, making chips mostly for their own use, but the merchant firms that sell semiconductors to systems makers are mostly smaller, entrepreneurial companies. Such companies have been highly innovative, but also highly unstable. Personnel turnover (especially defections to start new firms) is high, as are rates of entry and exit. Their relatively small size, instability, and irregular cash flow make it especially hard for them to raise the large amounts of capital required for semiconductor production. These factors exaggerate the short-term focus that is endemic in U.S. financial markets.[11]

Government policies that increase uncertainty also aggravate the problem. For example, in the 1980s, American business managers were faced with a very high dollar, which made it harder to sell goods abroad and to compete against foreign goods at home. The dollar finally began falling in 1985. But throughout the high dollar period of the early 1980s, the U.S. Government made no provision for firms working under that disadvantage. In contrast, the Japanese Government put in place special loan and loan guarantee programs to help Japanese firms cope with *endaka* (high yen) after the international accords that brought the dollar down in 1985.

The single most important step the government could take to improve the financial environment is to greatly reduce the Federal budget deficit, and eventually eliminate it. That would help to lower interest rates and allow the dollar to find a level that more accurately reflects the competitiveness of American industry (Figure 11 shows real long-term interest rates in the 1970s and 1980s.) It would also be a powerful signal to the business community that government could be relied on to provide some stability.

None of this means that American manufacturing is entirely a victim of circumstances beyond its control. U.S. companies are hobbled, but not crippled, by a financial environment that undervalues long-term investment. Some of the myopia of U.S. firms could be overcome through the will of top management. Against the general background of short-term decisionmaking, a few firms stand out as long-term investors. Many of these firms have done well.But the power of finance and accounting in American corporations has lifted financial specialists to

**Figure 11—Real Long-Term Interest Rates**

SOURCE: Organization for Economic Cooperation and Development (OECD), *Historical Statistics 1960-1987* (Paris, France: OECD, 1989), table 10.10.

[11]Dertouzos, et al., 1989, op. cit.

many top decisionmaking spots, and their biases could be difficult to overcome, especially if the rewards for managing for the short-term bottom line do not start to dwindle.

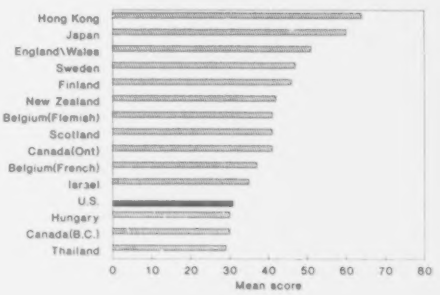
In the discussion so far, investment in technology has been defined as investment in capital equipment, research, and development. The United States also needs well-educated and trained people to make the best use of sophisticated technology. Currently, the investments we make in human resources have disappointing results.

Success in manufacturing depends on the competence and inventiveness of people at all levels. Increasingly, workers from the production line to the executive suite must be comfortable with advanced technology. Production workers are responsible for implementing statistical process control procedures; designers, line managers, and workers must interact frequently and productively; and everyone must assume broader responsibility for making high-quality products effectively. The skills demanded for these tasks are those of analysis and problem-solving. The days when most factory workers used their hands more than their heads are disappearing.

American workers are poorly equipped to cope with these changes, in part because our public schools do not educate many of our children adequately, and in part because firms have been slow to adopt production systems that demand higher order skills, and to train workers to use them. Firms, in turn, are often reluctant to invest heavily in training for fear that they will not be able to recoup their investments.

U.S. educational deficiencies are great in science and mathematics. In the mid-1980s, American junior high school students ranked 10th in arithmetic, 12th in algebra, and 16th in geometry in tests of mathematics competence in 20 countries. In a another comparison of students in 14 nations, American 12th graders ranked 12th in geometry and 13th in advanced algebra (figures 12 and 13). In the 1960s, American students performed as well as students anywhere in the world. Further evidence of deterioration is the decline in Scholastic Aptitude Test scores over the last quarter of a century.

**Figure 12—Twelfth Grade Achievement Scores in Geometry**



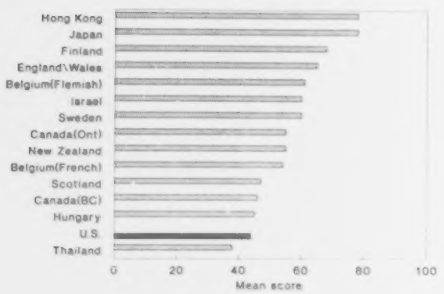

SOURCE: International Association for the Evaluation of Educational Achievement, *The Underachieving Curriculum: Assessing U.S. School Mathematics From an International Perspective* (Champaign, IL: Stipes Publishing Co., 1987).

Workers who cannot cope with mathematics or problem-solving are a liability in advanced manufacturing. For example, Motorola determined that workers in its Factories of the Future needed math skills equivalent to seventh grade proficiency to get by. Even this modest requirement has obliged Motorola to invest tens of millions of dollars in training.

Not only is our general public education inadequate, our vocational education system falls far short of the standards set by other countries. It certainly does not match the apprenticeship training taken by more than half the young people of West Germany. This system gets much of the credit for the broad diffusion of technical competence throughout German manufacturing.

While there are small indications of improvement—a recent turnup in SAT scores, for example—there is need for a great deal more. The fact that American students are behind those

**Figure 13—Twelfth Grade Achievement Scores in Advanced Algebra**




SOURCE: International Association for the Evaluation of Educational Achievement, *The Underachieving Curriculum: Assessing U.S. School Mathematics From an International Perspective* (Champaign, IL: Stipes Publishing Co., 1987).

of other advanced nations—and of several developing nations as well—makes it harder for the United States to keep up in manufacturing. Another worrisome trend is demographic. In the past, most engineers and scientists were white males; they now comprise a shrinking portion of the population of school-age children. Minorities and women have historically performed much less well than white males in math and science, for reasons that are only partly understood. To avoid a future scarcity of technologists, the Nation must devote particular efforts to improving math and science proficiencies—of students of both sexes and all races—all the way from grammar school to employer-provided training.

Do we need to invest more money? It is a widely held belief that the United States invests more in educating its children than other nations, both per capita and as a share of gross domestic product.[12] This is clearly true only if post-secondary education is included. A recent study that separated out education past high school found that U.S. public and private spending on schooling from kindergarten through 12th grade, as a share of GDP, is lower than in most industrialized countries—tied for 12th among 16 (figure 14). In spending per student in grades K-12, the United States ranks higher—5th of the 16 (figure 15).[13] The United States has some special educational problems: our population is much more diverse in culture and language than that of most of our competitors. It could well take heavier investments in human resources to solve our unique problems.

## PROMOTING COOPERATION

Partly because of American traditions—the emphasis on individual initiative, for example—and partly because of public policies that limit cooperation, U.S. firms tend to be isolated from customers, suppliers, and competitors compared with Japanese and many European firms. Japanese firms, in particular, are knitted into a network of mutual obligation and cooperation. This is not to say they don't compete; competition is fierce, but is often greater in product quality and features than in price.[14] The bonds of cooperation and obligation, together with relatively limited price competition in the Japanese market, provide Japanese firms with two advantages: access to a wider array of information and support than they would have alone, and enough stability to encourage investment in equipment, knowledge, and people.

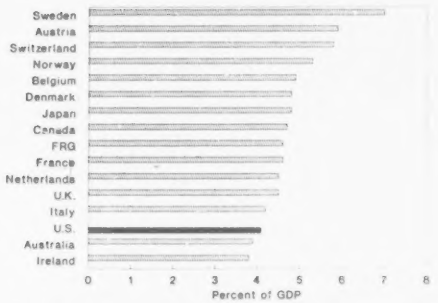
U.S. companies, on the whole, do not form strong collaborative links. The typical relationship between supplier and customer is distant, even adversarial. Price has been the major basis for dealings with both suppliers and competitors. This is not invariable, nor is it without

[12]For example, President Bush told the "Education Summit" in September that the United States "lavishes unsurpassed resources on [our children's] schooling."

[13]M. Edith Rasell and Lawrence Mishel, "Shortchanging Education," Economic Policy Institute briefing paper, Washington, DC, January 1990.

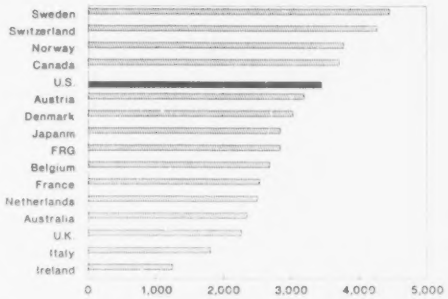
[14]The fact that prices of many consumer goods made in Japan are lower in the United States and other foreign countries than in Japan indicates that Japanese manufacturers do not always compete vigorously on price. Japan's complex distribution system accounts for some but not all of the higher retail price for many goods.

**Figure 14—Spending for Education Grades K-12, Percent of GDP, 1985**




SOURCE: Lawrence Mishel and M. Edith Rasell, "Shortchanging Education," Economic Policy Institute briefing paper, Washington, DC, January 1990.

**Figure 15—Spending for Education Grades K-12, Per Pupil, 1985**




SOURCE: Lawrence Mishel and M. Edith Rasell, "Shortchanging Education," Economic Policy Institute briefing paper, Washington, DC, January 1990; and U.S. Department of Labor, Bureau of Labor Statistics, unpublished data, August 1989.

advantages. In some industries—notably, the airline and aircraft industries—relationships between suppliers and customers are traditionally strong; and in some where relations used to be distant or hostile—such as textiles and apparel—they are becoming stronger. Moreover, price competition among suppliers or between competitors, is desirable and healthy. But taken too far, narrow reliance on price competition can sever close links between customer and supplier, and reduce incentives to improve quality and timeliness. Close and stable relationships with customer firms are incentives for supplier firms to invest in human resources and in equipment that may take several years to pay off. To illustrate the point, in a recent study of metalworking companies, about half the firms that had not bought numerically controlled (NC) or computer numerically controlled (CNC) machine tools cited lack of stable demand for their product as the reason.[15]

Both parent and supplier companies in Japan benefit from close, cooperative relationships. Without having to manage every detail, the parent company is able to demand favorable terms for costs, quality, and delivery times. The supplier has the advantage of a reliable customer who can provide assistance with technical problems and occasionally with finance if needed. While these relationships are often quite stressful for the supplier companies, they have promoted the diffusion of technology and know-how to Japan's myriad of small companies with remarkable effectiveness, aided by an abundance of Japanese Government technology diffusion programs. (See the following section on *Transferring Knowledge*).

In contrast, American companies have traditionally opted for one of two strategies: vertical integration, or arms'-length dealing with competing suppliers. While vertical integration could be thought of as the ultimate in close relationships, the control over cost that a company can exercise with an outside supplier may be sacrificed. And pitting suppliers against each other—making them compete for every contract on price with no assurance of ever getting another one—makes it more difficult to transfer technology and design responsibilities. The Japanese system has been a remarkably effective compromise. A measure of its effectiveness is that many American industries—the motor vehicle

[15]Maryellen R. Kelley and Harvey Brooks, "The State of Computerized Automation in U.S. Manufacturing," John F. Kennedy School of Government, Harvard University, 1988.

industry, as well as the textile and apparel industries—are making similar arrangements with their own suppliers.

Close relations between capital equipment suppliers and their customer firms are especially important to technological prowess, particularly in fast-moving industries like microelectronics. In the past two decades, American industry has become steadily more dependent on foreign manufacturers for its production machinery. Japanese suppliers have come to dominate the market for workhorse CNC machine tools; Swiss, German, Japanese, and other European makers lead the market for textile and paper industry machinery; and U.S. producers of semiconductor production equipment are fast losing the lead to Japanese rivals.

In textile industry machinery, where the domestic market share fell from 93 percent in 1960 to less than half in 1986, the reasons for the demise of most U.S. producers are instructive. The industry's decline, which began in the 1960s, was due largely to its unresponsiveness to customer needs and to a short-term perspective, reflected in scanty spending on research and development compared with foreign competitors. The neglect of R&D spending was made worse by the merger mania of the 1960s. Most of the U.S. textile machinery companies were bought by conglomerates.

Although the decline of the American textile machinery industry has not, it seems, crippled American textile makers. Nearly all report satisfactory service from their foreign suppliers. However, the situation is different in the semiconductor industry. As recently as 10 years ago, American firms held more than three-fourths of semiconductor production equipment world market. By 1988, the U.S. share was down to 47 percent and still dropping (table 2, figures 16, 17, and 18). This year, Perkin-Elmer, one of the major remaining U.S. manufacturers of lithography equipment, dropped out of that market, which had become a money loser for the company.

Already, losses in the American semiconductor equipment industry are a handicap for U.S. semiconductor producers. U.S. producers say that, for some critical production equipment, they are unable to buy the latest model from Japanese makers only after it has been in wide use by Japanese chipmakers for months. Many U.S. chipmakers are concerned that their ability to get state-of-the-art equipment will decline further in the future. The next generation of lithography equipment is expected to use X-rays, and the Japanese are well ahead of U.S. companies in developing X-ray lithography equipment. If commercial use of X-ray lithography equipment begins, as expected, in the 1990s, it is likely that the first use will be in Japan. That development would add to the already substantial number of microelectronics technologies dominated by Japanese producers.

Sematech, the U.S. industry-led consortium to develop a process to manufacture a 16-megabit DRAM, has given top priority to improving relations between chipmakers and equipment producers. Sematech's directors see better relations as essential to develop a range of high-quality, affordable equipment and materials for American producers.

U.S. producers of supercomputers also risk dependence on Japanese suppliers of components. Significantly, many of those suppliers are also competitors, making supercomputers themselves, or else are closely aligned with competitors. For example, the highest performance memory and bipolar logic components for supercomputers come only from Japan. The management of Cray, a U.S. manufacturer of supercomputers, has at times been told that the latest and best of these components are "not yet available for export" from Japan.[16] They are, however, available to Japanese supercomputer makers, and the Japanese supercomputers them-

[16]IEEE/USAB Committee on Communications and Information Policy, "U.S. Supercomputer Vulnerability," report to the Institute of Electrical and Electronics Engineers, Inc., prepared by the Scientific Supercomputer Subcommittee, Committee on Communications and Information Policy, United States Activities Board (Washington, DC, August 1988).

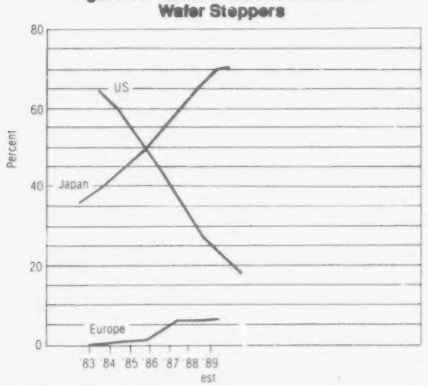
**Table 2—Top Ten Semiconductor Equipment Suppliers, World Sales**
**(millions of dollars)**

| 1982 | | 1988 | |
|---|---|---|---|
| Perkin Elmer | $162 | *Nikon* | $521 |
| Varian | 100 | *Tokyo Electron (TEL)* | 508 |
| Schlumberger | 96 | *Advantest* | 385 |
| *Takeda Riken (Advantest)* | 84 | Applied Materials | 382 |
| Applied Materials | 84 | General Signal | 375 |
| Eaton | 80 | Canon | 290 |
| Teradyne | 79 | Varian | 211 |
| *Canon* | 78 | Perkin Elmer | 205 |
| General Signal | 77 | Teradyne | 190 |
| *Nikon* | 58 | LTX | 180 |

(Japanese Firms *Italicized*)

SOURCE: VLSI Research, Inc.

**Figure 16—Shift in Market Shares for Wafer Steppers**




NOTE: The wafer stepper is a device central to manufacturing semiconductors.

SOURCE: VLSI Research, Inc.

selves *are* ready for export. Closer relations with U.S. suppliers is not just an advantage but a necessity for maintaining market share, in a world where a firm's major suppliers are its fiercest competitors.

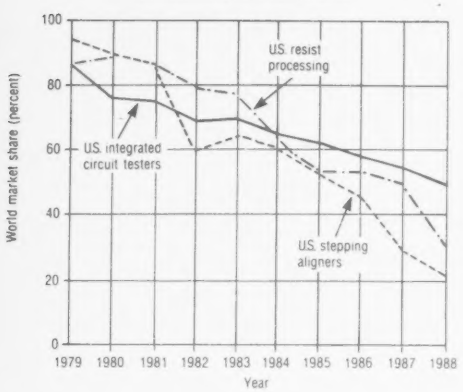
Another wellspring of Japanese technical prowess is cooperative research and development, which has the advantages of shared expenses and synergism. Participants in consortia to develop new products or techniques can gain access to research results they could not afford on their own, and have the chance to work with scientists or engineers from other firms and institutions.

Complex manufacturing processes and sophisticated products demand increasing inputs of research and development. The higher the cost of R&D, the riskier the investment—too risky, perhaps, for all but the largest and most stable firms. For example, it is costing billions of dollars to develop X-ray lithography, an amount that strains the resources of even giant firms. In Japan, a government-sponsored consortium is helping to share the risk and effort involved in developing commercial X-ray lithography.

R&D consortia have other attractions. For example, they are often effective at diffusing technology to participants; they help to avoid problems of redundancy, or wasting of resources on reinventing wheels; and they can be valuable training grounds for researchers. Especially when government is a participant, consortia can help to provide adequate investment in technologies that have a great many externalities—where the rewards cannot be captured by a single firm. In this way, consortia can help lengthen the short time horizons of American management.

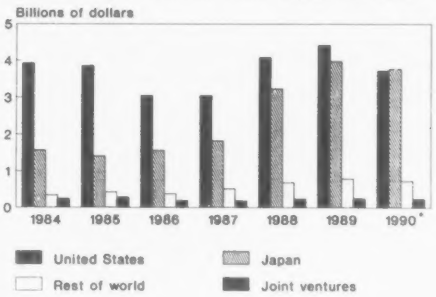
Consortia are not, of course, a panacea. They seem to work best when there are clear goals and least potential for conflict among members—for example, in catch-up projects, where no firm can hope to get a monopoly on a new technology. If America were in the competitive position it occupied two decades ago, we might well conclude that the case for stimulation of consortia (especially ones with government participation) is dubious. But that is not the situation. The

**Figure 17—U.S. Market Shares of Selected Semiconductor Equipment**




SOURCE: VLSI Research, Inc.

**Figure 18—World Semiconductor Equipment Sales**




* Forecast
SOURCE: VLSI Research, Inc.

United States has serious competitive problems to solve. The European Community, moreover, has opted to support a profusion of new science and technology consortia. These consortia are largely aimed at overcoming what are perceived as substantial foreign leads in a wide variety of technologies. While the EC's technology consortia probably will never amount to more than 10 percent of all the Community's expenditure on R&D, that small percent is viewed as critical, both because it adds to the amount spent, and because it gives the EC an important strategic lever for guiding European manufacturing technology.

American industry and government have moved cautiously toward collaborative R&D in the past few years. The Federal Government put up half the funding for Sematech, and it has contributed $5 million per year for 3 years to the National Center for Manufacturing Sciences, a consortium designed to do generic research on metalworking and other manufacturing technologies. The National Science Foundation's Engineering Research Centers offer another approach. ERCs are university-based centers that get half their funds from NSF, one-third from industry—which must cooperate with the university in generating and running the research program—and the rest from university, State, and local funds. This small program, encourages interdisciplinary engineering research and education and promotes cooperation among university and industry researchers.

One obstacle that sometimes hinders greater collaboration—more in downstream activities like manufacturing than in R&D—is our antitrust law. The discouragement comes not because all collaborative projects would actually violate antitrust law, but because the law is rather unclear, its penalties can be harsh, and trials are expensive. Antitrust law can also interfere with U.S. firms' merging to face competition from larger foreign firms.

These problems suggest the need for modest changes in our antitrust laws. They need to be made carefully, so as to preserve the laws' protection against price-fixing and other anticompetitive practices. Possible approaches include clarifying that conduct should be judged with full consideration of the long-term benefits of cooperation, reducing harsh penalties, and providing for advance approval of cooperative projects.

## TRANSFERRING KNOWLEDGE

Public and private institutions for diffusing new technologies across the manufacturing sector are thin in the United States. In particular, there is little technical assistance available to small manufacturing enterprises. While some small manufacturers are on the cutting edge of technology—the Silicon Valley startup springs to mind—most are not. Many cannot afford to devote the time and attention to keeping up with technological developments made in the United States, to say nothing of technical advances made abroad.

It is uncommon for large manufacturers in America to lend technical assistance to their suppliers—still less for the first line suppliers to pass along technical help to smaller subcontractors. Both are everyday practice in Japan. There is little in this country to compare with Japan's dense nationwide network of free, public technology extension services for small and medium-size firms. Nor do we have anything like the huge programs of financial assistance that accompany technical assistance to small and medium-size firms in Japan. In 1988, low-cost direct loans to smaller firms from Japanese national government financial institutions amounted to more than $27 billion, not to speak of $56 billion in loan guarantees, plus additional technical and financial assistance from prefectural and local governments.

In the United States, aside from some small programs for disadvantaged individuals, the Federal government makes no direct loans to small business. In fiscal year 1989, the Small Business Administration underwrote guaranteed loans worth $3.6 billion. A few States have industrial extension services to help small manufacturers make informed decisions about improving their production methods and implementing new technology. No accurate count is available, but these State programs are probably funded at about $25 to $40 millions per year. Federal involvement in industrial extension is sketchy, although Congress has recently taken some steps to strengthen it. The Federal program of technology extension consists mainly of three Manufacturing Technology Centers created in the Omnibus Trade and Competitiveness Act of 1988 and funded at $7.5 million in fiscal year 1990; three more centers are planned. Altogether, current industrial extension programs, State and Federal, reach only a small fraction—probably less than 2 percent per year—of the Nation's small manufacturing firms.

Government technical assistance to small manufacturers in Japan far outpaces similar programs in America. Because financial and technical assistance programs are interrelated, an estimate of the size of these programs is not available, but they are large. For example, Japan's national government provides half the funding for the nationwide system of 185 technology extension centers with the other half provided by prefectural governments. Total funding for the centers is over $470 million per year. Local governments support additional technology extension centers as well. But government assistance is not the only or even the major form of technical assistance. In a recent survey done by MITI's Small and Medium Size Enterprise Agency, 45 percent of respondents (small and medium-size businesses) reported that they received technical assistance from a parent company, 37 percent got information, 28 percent were loaned or leased equipment, and 24 percent got training for their employees.[17] In some cases, vertical transfer of technology within Japanese supplier groups is effective enough to allow major manufacturers to delegate other functions to their suppliers. Both Toyota and Nissan, for instance, have delegated assembly of some of their cars to former first-tier suppliers.

American companies—including all the Big Three motor vehicle companies—have instituted similar programs recently, becoming both

[17]D.H. Whittaker, "New Technology Acquisition in Small Japanese Enterprises: Government Assistance and Private Initiative," contractor report prepared for the Office of Technology Assessment, May 1989, p. 23.

more demanding and more supportive of their suppliers. They have pared down the numbers of suppliers, given more technical assistance, and are moving towards performance-based standards. But U.S. firms are still far behind Japanese manufacturers in diffusing technology and know-how along supplier chains, or among firms within an industry, or from public institutions to private firms.

Because of Japanese direct investment, some American firms are experiencing the Japanese system firsthand. According to a recent GAO study, U.S. auto parts producers who work with Japanese transplant assembly firms report that their Japanese customers keep in closer contact than their U.S. customer firms, and send many more staff on site visits to the supplier's plant. They characterized the Japanese companies they work with as "preventative" in solving problems, rather than "reactive," like American firms.[18]

Large U.S. firms as well as small ones suffer from isolation. Their customary arm's-length, adversarial relation with suppliers deprives them of the back-and-forth collaborative work on new technologies that takes place between large firms and first-line suppliers in much of Japanese manufacturing. This collaboration is important to innovation in Japan. Japanese manufacturers of all kinds of products, from automobiles to office copier machines, are quick to make incremental changes in products and bring new models embodying the latest technology to market ahead of their competitors.

Another contributing factor to firms' competitive position is their readiness to scan the world, find out what new technologies are available and plug them into new products. American firms seem much less inclined to exploit technologies that originate outside the firm—a stance often called the not invented here (NIH) syndrome. One study of 50 large Japanese firms and 75 large American firms found that Japanese firms spent considerably less time and money than the U.S. firms in developing new products and processes, mostly because the Japanese were adept at exploiting innovations made elsewhere, while American firms were trying to generate more of their innovation internally.[19] The ability to make effective use of external technology is also related to short product cycles. Japanese firms in automobiles and electronics have managed to pare product cycles so that they are shorter than those of American competitors. Since new ideas, from inside or outside, are most likely to be adopted at the beginning of a product cycle, shorter cycles mean more innovation—and they do, for many Japanese industries.

The reluctance of U.S. firms to adopt and work with outside ideas has not undermined their ability to apply big-bang, fundamentally new technologies that can be exploited commercially. American companies in general have been good at this, and many small startup firms have found venture capitalists to stake them. NIH applies more to technologies that are good for incremental improvements. It may also help to explain why U.S. firms take curiously little advantage of new technologies developed in Federal laboratories. However, another reason is that the labs, short of money for technology transfer and hampered by red tape, do not reach out to industry.

Most of the $21 billion per year spent on R&D in Federal labs is for defense or basic research—missions not directly relevant to commercial manufacturing. Some of this R&D could be made useful to civilian manufacturing, both by transferring lab technology to industry for further development and by lab-industry cooperative R&D on subjects of mutual interest. Although Congress passed several bills in the 1980s to encourage commercialization of technology from the Federal labs, such commercialization has been modest.

[18]U.S. General Accounting Office, *Foreign Investment: Growing Japanese Presence in the U.S. Auto Industry*, GAO/NSIAD-88-11, March 1988.

[19]Edwin Mansfield, "Industrial Innovation in Japan and the United States," *Science*, Sept. 30, 1988.

One main reason is that the labs' efforts at encouraging commercialization have not been adequately funded. Without line-item funding, such efforts are often considered by personnel at the labs and their parent agencies to be mere distractions from their primary missions. Interactions between the Federal labs and private industry require a new philosophy and new procedures, and the resolution of some difficult issues (e.g., potential conflicts of interest). Resolving them is more difficult when agency officials, such as the general counsel, put forward objections and there is no strong countervailing voice to push the process along. In addition, some provisions of the law hinder the labs from granting a firm exclusive rights to technology. Without those rights, firms may not find it worth their while to commercialize technology coming out of the labs.

Concerns about exclusive rights extend to R&D in general. Many American firms complain that in the United States and, especially abroad, their new products and manufacturing processes are copied by imitators who did not pay to develop them. They desire stronger intellectual property protection for new technology—chiefly patent rights, and copyrights for software. Without it, they assert, they face unfair competition and cannot pay for their R&D.

This argument has some merit, and some measures to increase protection would help. The most promising ones include strengthening patent enforcement in the United States and Japan, and negotiating to harmonize and eventually unify the patent systems of different countries. However, there are limits to the benefits to be expected from beefing up intellectual property protection. Developing countries may be induced to add some protection but, on the whole, they do not see stronger measures as in their interest. More generally, strong protection, while encouraging creation of technology, can inhibit its diffusion and, in the long run, cannot make up for disadvantages in manufacturing quality and cost. Therefore, while stronger intellectual property protection can help U.S. manufacturing competitiveness somewhat, measures to improve manufacturing quality and cost will help more.

## POLICY ISSUES AND OPTIONS

In building a stronger technological base for American manufacturing, both industry and government have important parts to play. Many of the things that must be done are squarely up to manufacturers themselves. Company managers have to learn to use their people more effectively by promoting a back-and-forth flow of people and ideas between research (or design) and production, insisting on design for easy manufacture, pushing simultaneous engineering of improved products and the processes to make them, and giving shopfloor workers the training and responsibility for improving efficiency and product quality. Likewise, it is managers' job to get the fat out of the American production system—for example, by trimming inventories that cost money and hide problems, and by organizing work for reduction of waste. And it is largely up to managers to make the most of forming cooperative relationships between large firms and their smaller suppliers, or between different segments of an industry complex.

There is also much that government can do. Traditional U.S. R&D support, mainly for defense and science, has been beneficial to the Nation as a whole and often to industry in particular, but it is not enough to maintain technological leads, or even parity, in most industries—especially since most of the other OECD nations are making greater efforts to advance civilian technology.

First, government policies that create an environment more conducive to manufacturing make it easier for companies to concentrate on the things that only *they* can do to improve technology. For example, if government policies succeed in lowering the cost of capital to business, or lifting some of the pressure for short-term profits, they are "preparing the ground" (as the Japanese say) for business to do its job well.

Government can also take more direct actions, some within traditional U.S. policy, and others less so. Starting with broad policies affecting the financial environment and human resources, they could go on to stepped-up programs for active diffusion of technology to private firms and, still further, to a strategic approach that would target government R&D support to critical technologies.

The possibilities for government action do not stop there. Many governments throughout the world use means beyond R&D support to promote industries they consider strategically important. For instance, they may favor certain industries with low-cost capital or government-guaranteed purchases, and they may add further support with trade policies designed to manage competition from dominant foreign producers during developmental phases. In building up its industrial might, Japan relied heavily on coordinated technology, industry, and trade policies to promote key industries. Korea and Taiwan followed Japan's lead, and the European Community is using many of the same industrial and trade policy tools as it prepares for the European single market in 1992.

Whether the United States should or even could try to use such comprehensive government policies to bolster competitiveness will be considered in another report, the final one in OTA's assessment of Technology, Innovation, and U.S. Trade. That report will discuss industry and trade policies of Europe and the Asian rim countries, and in what way they might be relevant to the United States.

In this assessment, the spotlight is on technology. The policy options (summarized below) are directed toward four principal strategic aims:

- **Improving the financial environment** for U.S. manufacturing firms. This means lowering capital costs and relieving other pressures in the financial markets to show high short-term profits every quarter. The goal is a more hospitable environment for long-term investment in new technologies and productive equipment.
- **Upgrading education and training** of the workers, managers, and engineers needed in manufacturing. U.S. manufacturing suffers from the failings of our public schools, but also from failures of managers in organizing work and training people to use advancing technologies effectively. Besides continuing efforts to improve education generally, government can help with the retraining of active workers and the betterment of manufacturing engineering.
- **Diffusing technologies** throughout the manufacturing sector. Government can be much more active than it has been up to now in helping manufacturers acquire up-to-date production equipment and learn to use it effectively. Options might include stepped-up Federal support for technology extension services and a subsidized equipment leasing system. Such things as easier access to technologies coming from Federal labs or foreign countries could benefit all U.S. manufacturing.
- **Supporting R&D for commercially important technologies.** Some technologies of great potential benefit to society do not get adequate private backing because the payoff for individual firms is too small, uncertain, and far in the future. The U.S. Government has sometimes given special support to R&D for commercially important technologies, but in an ad hoc rather than proactive way. A coherent, strategic technology policy requires having an agency in charge that can set goals and choose technologies to support that fit the goals.

### *Improving the Financial Environment*

To keep up with the competition, U.S. manufacturing firms need two basic things that are mainly the province of government to supply: well-educated workers and capital costs that are not so high as to be disabling. As matters stand, government in this country is not doing well at supplying either of these necessities.

The combination of massive government dissaving (the Federal budget deficit, at historic highs in the 1980s) and anemic personal and business saving (at historic lows in the 1980s) is a powerful force driving up interest rates and the cost of capital to business. Congress has made some progress in reducing the Federal budget deficit but it remains high. Some combination of higher revenue and lower spending over several years will be needed to reduce the budget deficit, and this poses a problem. Many of the policy options suggested in this report would, all other things being equal, have a contrary effect, because they would entail either increased tax expenditure or reduced revenue. If these or other policies are not to have the perverse effect of increasing the deficit, even stronger measures would be needed to reduce it. If the United States succeeds in restoring its strong competitive position, then economic growth will help to shrink budget problems in the future. There will be a price to pay in the short run for improving manufacturing, but if it restores our ability to raise standards of living for the great majority of Americans in the long run, it will be worth it.

The budget deficit is a significant source of upward pressure on interest rates, but not the only one. To make capital less costly, the supply available for capital formation must also be expanded. That means raising domestic savings rates. Although the personal savings rate has risen from its extreme low in 1987—less than 2 percent—it is still below the U.S. norm of 6 to 8 percent, and far below the rates in Japan and most European countries. Some analysts argue that the United States can continue to rely on foreign capital to make up the difference between domestic investment and domestic savings, but that is inconsistent with lowering capital costs. It takes high interest rates to attract foreign capital.

To encourage household savings, Congress could consider a national savings initiative, which would reward increases in regular savings (e.g., payroll savings) for households in all tax brackets. To be effective, such a campaign would need to include several substantial savings inducements, such as guaranteed interest rates, high enough to be attractive, on widely available savings instruments. One suggestion is for a new type of government bond with a fixed coupon rate. Reducing taxes on the interest income to regular savings could also be considered.

Inducements to save may not be sufficient to raise savings rates or promote capital formation in industry without some accompanying measure to discourage consumption. Congress may wish to consider a consumption tax, scaled to tax luxury items most heavily, or with substantial exemptions to avoid the severe regressivity of a flat consumption tax. Another possibility is to limit the deductibility of interest paid on home mortgages more severely. There are some limits now, but they are set very high; this encourages consumption of housing and builds equity for households, but the capital tied up in housing is not available for industrial capital formation.

The measures suggested above could help to bring down interest rates generally, and that would tend to lower capital costs. Interest rates and capital costs are not synonymous, however; capital costs are also a function of taxes and of relationships between capital suppliers and companies. Several measures could help to lower the cost of capital to U.S. companies even if general interest rates remain high. One set of options Congress might wish to consider is special tax inducements for technology development and capital investments. The United States has tried a few such measures in the past. For example, the Accelerated Cost Recovery System (ACRS) and the Investment Tax Credit (ITC) were designed to promote capital investment, and the research and development tax credit to increase R&D spending. While the effectiveness of these measures is debated, there is enough substance to the arguments in their favor that they (or measures like them) are worth considering. And they should be considered separately, for they are very different. ITC and ACRS were very expensive (costing tens of billions of dollars, when they were in full force); such measures could, if designed carefully, promote mainly

improvements in manufacturing technique. The R&D tax credit is far less expensive, and has more effect on new technology development than on current practice.

Another set of forces affecting capital costs, especially for long-term investment in technology development and capital equipment, is the current wave of hostile takeover activity and speculative turnover of stock. This activity, and the threat of it, reinforces the effect of high capital costs in impelling managers to focus on short-term profits. The relative influence of the takeover boom and high capital costs is a controversial matter which OTA does not resolve. Nonetheless, it is reasonable to conclude that takeover activity is a significant damper on managers' willingness to commit resources to long-term projects, or to retain earnings for reinvestment. The pressure from this source might be manageable if overall capital costs were lower, or if there were enough effective countervailing measures to promote higher levels of investment in R&D and capital equipment purchase.

As it is, Congress might wish to consider mitigating the pressures of hostile takeover activity by means of incentives for investors to hold investments longer. This might be done by adjusting the capital gains tax rate to favor long-term gains and penalize short-term asset turnover. This measure would have most effect if the tax were extended to pension and other funds that are currently tax-free, but account for more than half the transactions in the financial markets. Another option is to tax securities transactions, which would penalize those whose turnover is greatest. However, without real, steady progress toward eliminating the budget deficit, all of these other measures taken together will probably have only a marginal effect.

Finally, the financial environment of the United States is unstable and unpredictable, compared with our premier international competitors, Japan and West Germany. In Germany, in particular, macroeconomic policymaking concentrates on maintaining stability in prices and exchange rates and controlling inflation. Such stability is an enormous asset to business, especially in a country that is heavily dependent on foreign trade (like West Germany), and especially when supplier-manufacturer-customer links are increasingly likely to span national borders (as the 1992 European Single Market approaches).

Japan's financial environment is also very stable. Policymakers there are highly sensitive to how macroeconomic developments affect business, and they take steps to help the private sector adjust. For example, after the international financial accords were reached to raise the value of the yen (and other currencies) against the dollar in the mid-1980s, the Japanese Government put in place loan programs to help firms (small ones, in particular) adapt to the rising yen *(endaka)*. Japan's economy did slow down in 1985 and 1986, at the beginning of *endaka*, but the adjustment was swift. Much more painful were the circumstances faced by American manufacturers in the early 1980s when the dollar began its long climb, and no government policy was in place to ease the adjustment. In sum, a major difference between Japanese and U.S. policies is that little concern is evident in the United States about the effects of macroeconomic, trade, and other policies on the competitiveness of U.S. firms in general or manufacturers in particular. In Japan and West Germany, competitiveness is customarily taken into account. It plays a prominent role in making and implementing those governments' policies.

### *Human Resources*

Human resources, like capital costs, have a pervasive effect on manufacturing. In the past, most manufacturing workers learned their jobs by the sides of more experienced workers, and an ordinary grammar school or high school education was plenty of preparation for a production worker in manufacturing. Today, with automation affecting more workplaces and less automated work being exported overseas, production jobs in manufacturing require more conceptual knowledge—and often competence

in statistical process control and managing computerized equipment. Jobs typically encompass more diverse tasks than in the past, and workers must grasp the relationships of different parts of production to each other in ways never required before. In other words, more is demanded of manufacturing workers. At the same time, the typical American education is leaving young people less well prepared for their worklives. Managers have remarked for years that young people could be better prepared, but the situation now is commonly described as a crisis. And it is likely to get worse before it gets better. About half the new entrants to the work force between now and the turn of the century will be members of minority groups, and about two-fifths of minority children live in poverty. Poor children typically drop out of school in disproportionate numbers, and many grow up lacking the skills they need to be productive workers.

There is a broad consensus that the Nation's public school system needs help. But even if help arrived tomorrow, the results would be many years coming. A more immediate approach is to help people already in the work force to acquire needed skills. While some large companies are providing education and training themselves, the financial burden of such programs—good ones can run into hundreds of thousands to millions of dollars—is another drain on limited financial resources. Most small companies cannot afford extensive training programs.

Congress could consider several options to help workers raise their educational levels and improve their work skills. One is to offer federally guaranteed student loans to employed people taking classes part-time; another is to let employers and employees deduct the costs of training and education (the present tax law already allows this, subject to some limitations). Another possibility is to tailor military training programs, which are already extensive, to fit more closely the skills required of workers in civilian jobs. The Federal Government provides less than $10 million to a program that partially funds demonstration projects for literacy teaching in workplaces. There is ample evidence of additional demand for such projects; increased funding could be used effectively and immediately. Training could also be made a part of any technology extension services offered by the Federal Government or funded in part by Federal money, (See the section below on *Technology Extension.*)

These suggestions do not constitute a complete list of options for training active workers. A fuller examination of the possibilities for congressional action will appear in a forthcoming OTA report, *Worker Training: Implications for U.S. Competitiveness.*

Although well-educated and trained production workers are essential to improving manufacturing efficiency and quality, there are other, equally critical needs for highly trained people. Production workers are a steadily falling percentage of manufacturing employment; professional and technical employees are a growing share. Engineers, in particular, are essential for excellence in manufacturing. It could be more difficult in the future to maintain an adequate supply of engineers to sustain manufacturing.

There is not now an obvious shortage of engineers in manufacturing; about as many engineers are employed per thousand workers in the United States as in Japan and Germany, whose manufacturing is justly famous for its excellence. But Japan is graduating more engineers per capita than the United States, and Germany has what is probably the world's finest set of training institutions to provide technical people for manufacturing, from the shopfloor to the engineering workstation. Meanwhile, in the United States, the demographic group most inclined to enter engineering—white males—is shrinking as a proportion of young people.

This trend is not new. Several Federal programs, are already in place to encourage women and minorities to enter engineering. Larger programs support the recruitment and training of students generally in scientific and technical careers, and special training for teachers.) Many of these programs are producing good results

and could be expanded. But without improvement in math and science education in the elementary and high schools, their effects are bound to be limited. Children who perform poorly in elementary school arithmetic and math are unlikely to choose engineering careers. General education improvement, especially in math, is the first necessity for keeping the engineering pipeline filled.

Some possible programs could help shore up the supply of engineering talent for the next few years, before improvements in education (if they are made) begin to yield results. If defense programs wind down as expected over the next few years, Federal programs might help retrain and equip engineers who have been working in the military sector to enter civilian manufacturing. More generally, programs to encourage or fund midcareer training of engineers whose knowledge needs updating might be considered.

The effective use of engineers is at least as important as an adequate supply. There are indications that U.S. manufacturers could make better use of their engineers. Elitism among engineering staffs, and their aloofness toward shopfloor problems in producing their designs, are often cited as a peculiarity of American manufacturing. This kind of problem is best solved by manufacturers themselves, but the Federal government could encourage manufacturers to recognize and correct the problem, through support of education and research in manufacturing engineering. One option is to increase Federal support of manufacturing engineering, possibly through the creation of a Manufacturing Sciences Directorate in the National Science Foundation.

### *Diffusing Manufacturing Technology*

Making the financial and human resource environment more conducive to improved manufacturing quality, efficiency, and technology may not be enough. American manufacturers have lost too much ground to foreign manufacturers, in nearly every sector. Even with lower capital costs and more competent people, some manufacturers may still lack the resources or the knowledge to find or develop and implement the best technologies.

Congress might consider an array of options to promote technology diffusion and transfer more widely, or remove obstacles to diffusion. None, by itself, will make a great deal of difference; patience and an experimental approach will be required to make any of them work. Some may fail. Yet it is likely that some combination of policies to promote technology transfer could pay off handsomely, given time, the commitment to adapt to changing circumstances, and the willingness to learn from experience.

#### Technology Extension

Large firms generally have the resources to develop or acquire technologies they need, although they may neglect to take what they could from outside the firm. But many small firms have a hard time staying abreast of advancing technology. Americans like to cherish the notion that all small firms are like Silicon Valley startups—technically and scientifically advanced, staffed and run by entrepreneurial innovators—but the image is hardly typical of small manufacturing firms. For many of America's 355,000 small and medium-sized manufacturing firms, exposure to new technologies is haphazard, and the effort to keep informed is beyond their means.

To contribute to the competitiveness of U.S. manufacturing, small firms need to keep up with technology as much as large ones. While small enterprises are usually not heavily involved in foreign markets themselves, their performance is important to the ability of larger manufacturers, who are their customers, to compete. Large auto companies, for instance, depend on the ability of their myriad suppliers, some of which are quite small, to deliver the right components, well made, on time. As specifications become more exacting, and the tolerance for defects decreases, the demands for small firms to use new technologies effectively grow. America's most adept competitors, Japan and West Germany, have broad, deep institutions that support

technology diffusion and transfer to small enterprises.

Large firms can transfer technology to smaller companies quite effectively themselves. Even in Japan, however, an extensive network of government programs and institutions to support technology diffusion and training supplements these private efforts. The United States, in contrast, has a few State programs and, until recently, very little at the Federal level. In 1988, the combined technology transfer and technology/management assistance programs of the 30 States that had such programs came to $58 million, and that included assistance to all kinds of business, not just manufacturing. State industrial extension programs, giving one-on-one technical advice to individual firms, probably add up to about $25 to $40 million per year.

The Federal programs include: 1) three existing and three more planned Manufacturing Technology Centers to demonstrate advanced technologies and provide extension; 2) some assistance to State programs; and 3) the Advanced Technology Program, a mechanism for Federal guidance and participation in joint R&D ventures with private firms. Together, the three programs have funding of less than $19 million for fiscal year 1990. A smattering of other Federal programs also offer some technology extension services; the largest of these is Trade Adjustment Assistance for firms and industries, funded at less than $10 million in fiscal year 1990. These small, scattered programs contrast with billions of dollars' worth of financial and technical assistance to small and medium-sized enterprises in Japan, plus Japanese Government participation in dozens of R&D efforts. While precise comparisons of funding for technical assistance to small manufacturing enterprises are impossible, it is certain that Japan's commitment to upgrading the level of technical ability in small firms is more than an order of magnitude greater than that of the United States.

If Congress wishes to deepen its commitment to upgrading technology in small and medium-sized manufacturing enterprises, it could increase funding for the Manufacturing Technology Centers, provide more money for State industrial extension services, or some of both. Manufacturing Technology Centers are managed by the National Institute for Standards and Technology, as authorized by the Omnibus Trade and Competitiveness Act of 1988. They are responsible for transferring technologies developed at NIST to manufacturers, making new technologies usable by small firms, providing technical and management information to small firms, demonstrating advanced production technologies, and making short-term loans of advanced manufacturing equipment to manufacturing firms with fewer than 100 employees. Although funding was authorized at $20 million per year, appropriations have been much smaller: $5 million in fiscal year 1988, $6.85 million in 1989, and $7.5 million in 1990. These amounts cover administration as well as technology extension activities. The three existing Centers have each received $1.5 million per year for their first 2 years, and must match the Federal funding. Federal funding starts to decline after 3 years, and drops to zero after 6 years.

In addition to the Manufacturing Technology Centers, the 1988 trade act authorized a program of Federal assistance to State technology agencies, administered by NIST. This program received no funding until fiscal year 1990, when Congress gave it $1.3 million to help States with industrial extension programs expand those programs. States receiving Federal money from this program must match it with their own funding.

Only a few States have real industrial extension services. (NIST, in a nationwide study, found only 13 that met their definition of "technology extension services," but more have since been established.) Several of those are quite new. Nonetheless, State programs are generally better developed than Federal ones, and a very few have years of experience.

There is room for expansion of both State and Federal efforts in technology extension. States may do a better job of service delivery, being in better touch with the needs of local manufacturers. But there may be some things the Federal Government can provide that States cannot. By their nature, industrial extension offices specialize in the industries most prominent in their service delivery area. And industries tend to be regionally concentrated, spanning State lines; Federal services are often better suited to serve regional concentrations of industries. Also, while some State programs are excellent, others are less so; a Federal service could help ensure consistent quality of service, or at least minimum standards. If Congress wishes to consider expanding efforts in support of industrial extension, financial support for good State programs, as well as technical and financial support for States which are new to the effort, would be an effective combination with support of Federal extension services.

If Congress were to set a minimum goal of extending industrial extension services to 24,000 small firms per year nationwide (7 percent of the nation's 355,000 small manufacturers), the total cost would be $120 to $480 million, depending on the level of service. If the Federal share of funding were 30 percent, as it is in the Agricultural Extension Service, the cost to the U.S. Government would be $36 to $144 million. That would provide a modest level of service, one that might easily be overwhelmed by requests for assistance. The State of Georgia's experienced, effective industrial extension program serves a roughly similar proportion of its manufacturers, and Georgia Tech, which operates the service, reports that it does not advertise because it would be swamped with requests it could not meet. However, considering the inexperience of State and Federal Governments in providing industrial extension, moderate annual increases may be all that could be handled now.

### Financial Aid for Modernizing Manufacturing

Technical assistance to small business is often most useful if it is accompanied by financial aid. Improving the general financial climate for investment or offering special incentives to invest in research, development, and capital equipment, will help all businesses. But small businesses still have special problems raising capital. They usually must pay more for both debt and equity capital, and they often do not have enough retained earnings to finance modernization programs or training on their own. Without help in financing, small firms may not be able to implement the advice of industrial extension services.

In fiscal year 1989, the Federal Government made 47 million dollars' worth of direct loans to small businesses run by special groups (disabled veterans, the handicapped, and others), and guaranteed $3.6 billion in commercial loans to small businesses. It contributed $154 million to investment corporations, which make equity investments and long-term loans to small businesses. These programs are not confined to manufacturing. None is aimed at improving the practice of manufacturing in general.

These programs are in striking contrast, both in funding and in purpose, with Japan's financial assistance to small and medium enterprises (SMEs). Japan's SME programs spend $27 billion annually in direct loans and an additional $56 billion in loan guarantees. Again, this funding is not confined to manufacturing (which makes it comparable to the figures given above for American programs). Much of the Japanese funding is tied to technical assistance, and some is directly targeted to technology improvement. Part of the reason for such heavy support to SMEs in Japan is that for many years, small business was a technological backwater. The same is true in many sectors of American small business.

There are, of course, important differences in manufacturing in Japan and the United States. One is that small firms play a bigger role in Japan's manufacturing sector—74 percent of manufacturing employment is in small and medium-size firms in Japan, compared to 35 percent in the United States. However, because

of the larger size of the U.S. economy, the difference is less in absolute terms. Small Japanese manufacturing firms employ 10.7 million people, compared to 6.8 million in the United States. In both countries, small manufacturing plants play key roles as suppliers to the large corporations that are major actors in the world economy. And in both countries, small manufacturing firms' needs for technical and financial assistance have much in common.

Congress might consider several options to encourage firms to invest more in advanced technology and in training support required in the service and to use the technology well. One option is an equipment leasing system that would make new production equipment available to manufacturers on below-market terms. If the system bought U.S.-made equipment could serve two related purposes: besides enabling firms to get advanced equipment on easier terms, it could also help assure U.S. makers of production machinery a market for at least part of their output. In both ways, the program would help American manufacturers to focus more on long-term investment and improvement. The program could be open only to small manufacturing business, or to all manufacturers, possibly with more favorable terms for smaller firms.

Another option to encourage technological improvement in small business is more direct financial support. As noted above, the government's financial support (loans, loan guarantees, and investments in development corporations) was about $3.8 billion in 1989. This compares with $487 billion in fixed investment (structures and producers' durable equipment) by all private business in the same year. While exact comparisons with Japan are not possible, we do know that Japanese loan and loan guarantee programs to small firms are *at least* 20 times greater than those of the United States, and the level of subsidy in Japan is more substantial. For example, even a federally guaranteed loan to a small business in the United States may be a couple of percentage points above the prime rate, while in Japan, government-guaranteed loans to small business are typically substantially below market rates, and in some cases interest-free. While Japanese policies clearly are not a template for American action, they do make a difference in the competitiveness of Japanese industry at all levels.

Greater financial aid for small manufacturers could offer an opportunity to upgrade technology. One qualifying condition for financial aid (either direct loans or loan guarantees) could be that the firm receive a technical assessment, possibly from an extension service, and that it either follow the guidance of the assessor or work out an alternative plan. This is not necessarily intrusive. From the late 1970s through 1989, hundreds of small U.S. firms injured by import competition received technical help from a small U.S. Government program, Trade Adjustment Assistance for firms.[20] (The program, formerly funded at about $15 or $16 million per year, including assistance to industries as well as firms, has been substantially reduced. Its fiscal year 1990 funding was $9.9 million in new and carryover funds.) An assessment was a precondition for assistance under the program, and many participating firms found it a valuable service. Many small firms in Japan voluntarily undergo assessments each year in order to learn of new techniques and markets, and to get an independent (though not detailed) assessment of the directions competitors are taking. This option presupposes an industrial extension service that could deliver competent, timely service nationwide.

Another possibility is to target financial aid to investments in advanced equipment, as Japan has done several times. Recently, for example, producers were allowed to depreciate automated electronic ("mechatronic") equipment very rapidly, encouraging many small and medium-

[20]For a description and analysis of the program, and the larger and better known program of Trade Adjustment Assistance for workers, see U.S. Congress, Office of Technology Assessment, *Trade Adjustment Assistance: New Ideas for an Old Program*, OTA-ITE-346 (Springfield, VA: National Technical Information Service, 1987).

sized firms to acquire numerically controlled machine tools. A drawback is that some firms might invest in equipment they aren't prepared to use properly; but a technical assessment or industrial extension service could help here.

Financial and technical assistance to small firms could be explicitly extended to cooperatives of small firms as well. Managers of small firms, with too few staff to dedicate even one person to keeping up with technology—or for that matter, with competitors, customers, or suppliers—often have to depend on a few ad hoc sources for information about changes that affect their business. Cooperative networks can help these managers in many ways, by pooling the time and resources needed to keep up with technology, changing markets, customers' needs, and competitors' doing by obtaining quantity discounts on equipment that individual firms buy in ones or twos; and by providing an independent source of information on new technologies that does not have its own commercial interests at stake, as vendors do.

If Congress wishes to support the formation of cooperative associations, it could consider making the services of federally funded industrial extension services available to cooperatives, or extending financial assistance to cooperatives as well as firms. Congress might also want to make provision for small firms to cooperate in marketing and manufacturing without risking violation of the antitrust law.

**Commercialization of Technology From Federal Laboratories**

The Federal Government spends $21 billion each year on R&D in Federal laboratories, of which three-fifths goes to defense applications. Some of the defense R&D could be useful to civilian industry, along with some of the basic research done for nondefense applications in Department of Energy (DOE) laboratories. For example, industry has benefited from using specialized facilities at some DOE labs, such as the Synchrotron Light Source at Brookhaven National Laboratory and the Combustion Research Facility of Sandia National Laboratories.

On the whole it has not been easy for industry to take advantage of the labs' technology—despite legislation enacted throughout the 1980s to facilitate the process. There are still obstacles on the Government's side, and further measures by Congress could help, although ultimately success will depend on industry's willingness to tap into the labs.

Congress could consider earmarking some of the labs' R&D appropriation for promoting commercialization. This would include identification and marketing of promising technologies, patenting when appropriate, and cooperative R&D projects to bridge the gap between the laboratory and commercial exploitation. Earmarking some funds for cooperative R&D could be particularly beneficial. (DOE's high-temperature superconductivity pilot centers in three national laboratories are examples of cooperative R&D projects, planned from the start with industry and funded 50-50 by industry and the labs.) Congress might begin by mandating that a few percent of the labs' budgets be set aside for cooperative projects as appropriate. This would encourage labs to seize opportunities for cooperative work promptly.

Another possibility is increased funding for the Federal Laboratory Consortium. The FLC, with a small central staff and volunteer representatives from over 300 labs, tries to match inquiries from firms with the appropriate lab researcher. Additional funding could help the FLC to perform this function, and also to increase its projects demonstrating new means of technology transfer.

In addition, Congress could consider measures to remove several obstacles to technology transfer and cooperative R&D. For example, DOE's national labs have sometimes been stalled by Agency red tape when they wish to license technology to firms. Congress has already taken some steps to give the labs more independence in this regard and could go further (e.g., by extending to all labs the power to take automatic title to patents from lab research, removing the necessity to wait for extended

agency review). To make cooperative projects more attractive to industry. Congress could also clarify DOE's right to keep information developed in the projects proprietary, and allow copyright of computer software created by government employees involved in such projects.

Lab-industry cooperation raises several other issues, such as possible conflicts between lab employees' duties at work and their desire to get consulting work or royalties from the commercialization of their work. Congress could consider forming an interagency legal task force which could give a broader perspective than a single agency has on these and other legal issues raised by lab-industry cooperation. The task force's approval would not be required; but an agency's general counsel, if concerned about an issue, could seek the task force's advice.

**Tapping Into Japanese Technology**

American firms are often faulted for not making greater efforts to investigate and import technologies developed elsewhere—sometimes, even in another division of the same firm. When U.S. firms were technologically dominant in most industries, this parochial attitude was no great handicap. Now, with technological advantage more evenly distributed around the globe, it is a significant hindrance. Many firms have responded to the challenge to keep up with technology developed abroad, but they face special difficulties getting access to Japanese technologies. One is simply the language. European languages are enough like English, and enough Americans know some European language, that it is not too hard to get the gist of technical articles or to have them translated. But the Japanese language poses much more serious translation problems. Another difficulty is that much of Japanese technology is developed in the industrial sector and thus is inherently less accessible than technical expertise and knowledge freely available at universities and other public or quasi-public institutions.

A sprinkling of U.S. programs promote technology transfer from Japan. A few universities have fellowship programs that send graduates in science and engineering to Japanese companies and research institutions; and the National Science Foundation and the Government of Japan sponsor several new programs to support long-term research by U.S. engineers and scientists in Japan. The NSF-Japan programs were not fully subscribed as this report was written, although there is reason to believe that they will attract more applicants as they become better known. Congress may wish to monitor the progress of government-supported programs, and provide additional funds when and if they become overcrowded.

Other options are to establish a Congressional U.S.-Japanese Fellowship Program, and to encourage government researchers working in Federal labs or elsewhere in the Federal Government to undertake long-term projects in Japan. Postdoctoral or midcareer fellowships for professionals other than scientists and engineers could also be useful, not in directly transferring technology, but in helping more people to understand the workings of Japanese management and government-industry relations.

Congress might wish to consider increasing the funding for the Office of Japanese Technical Literature. While demand for the office's products has been disappointing, expanding the services available could create more interest. Finally, the government could promote Japanese language instruction in public schools, possibly by examining the critical foreign languages program in the 1988 education act to see if it gives sufficient weight to Japanese. Another option is to fund expansion of Japanese language programs in post-secondary and postdoctorate education, especially for scientists and engineers.

**Antitrust**

Antitrust law and enforcement have been relaxed in the past decade, but fear of running afoul of antitrust statutes is still a potent force in industry, because the law is complex and often vague, penalty for violation can be stiff, and private parties as well as the government can

bring suit under the laws. There is good reason for firm enforcement of antitrust law; for many years, it has served this country well in maintaining competition. However, some kinds of cooperation among firms could help American competitiveness, and some modest changes in antitrust law and enforcement could help promote them.

Congress has already amended and clarified the law to make some joint activities easier. Among other provisions, the National Cooperative Research Act of 1984 clarified that joint R&D (as defined in the Act) will be judged under the rule of reason if suit is brought. This rule ensures full consideration of the activity's pro-competitive effects. Congress might wish to consider extending this provision to joint manufacturing and standards-setting. The 1984 Act also reduced private treble damages to single damages for registered R&D projects. Congress might wish to consider reducing treble damages in other circumstances as well.

Advance certification for some kinds of joint activities is another option. Firms could apply to the Justice Department for a determination that a proposed project complies with antitrust law. Private parties could challenge that determination in court but could not collect damages for activity covered by it. Another possibility is to establish safe harbor market shares, below which firms would not be in violation. Finally, Congress could make findings that joint ventures or mergers between U.S. firms are sometimes necessary to fend off foreign competition, and could instruct courts to evaluate such activity based on long-term effects.

Whether modifying the antitrust laws or their enforcement would unleash a great deal of cooperative work, and whether such changes would substantially improve manufacturing competitiveness, is unknown. It is also unknown whether changes such as those suggested would have substantial negative effects from lessening the fear of antitrust suits—effects such as increased hostile takeover activity or more price-fixing. Changes in antitrust law and enforcement should be made cautiously, but they deserve serious consideration.

**Innovation and Intellectual Property**

Improvement of intellectual property protection could well start at home. Within the United States, the greatest complaint is that patent enforcement is slow. Patent cases that go to trial take, on average, more than 2 1/2 years before a decision. Congress could consider several ways to speed up enforcement of patent infringement statutes. It might designate special judges for patent cases, or increase judicial manpower devoted to hearing patent cases. In a way, there is already extra judicial manpower available; the International Trade Commission employs four administrative law judges to hear cases under Section 337 of the Tariff Act of 1930. Under section 337, a U.S. firm whose patent is infringed by imported goods can apply for an order to stop the goods from entering the country. The procedures for hearing and settling cases brought under Section 337 have been found to violate GATT, however, and the Administration is considering how to amend Section 337 to satisfy GATT while keeping its advantages of a quick trial and enforcement at the border.

Effective domestic intellectual property protection is not sufficient, however. U.S. firms need adequate protection in foreign markets as well To many innovative companies, the Japanese patent system is a particular problem. It is slower than ours in issuing and enforcing patents, and it strongly favors licensing of patents—something U.S. firms do not always wish to do. The Administration is pursuing negotiations to fix these problems. Another problem for American firms is that they don't understand the Japanese system very well, and can't easily find out more. The language barrier adds to the difficulties. Congress might wish to establish a program in the U.S. Patent and Trademark Office to collect and disseminate information about the Japanese system.

Differing patent systems throughout the world present a general problem. Usually, a firm must

apply for a patent in each country in which it wants protection; this is expensive and time-consuming. One option is to harmonize international patent law and application procedures, at least among nations that trade heavily in high-technology products. The United States has been negotiating with Japan and the countries of the European Community to this end. Any agreement will probably require substantial changes in the U.S. patent system. While such changes—e.g., changing to a first-to-file system rather than first-to-invent—will be controversial, Congress might give any such proposal serious consideration, since a harmonized (and eventually unified) system could take much of the time and expense out of obtaining international patent protection.

### *Strategic Technology Policy*

With few exceptions, the U.S. Government has been reluctant to adopt proactive policies to build competitiveness. For generations, most American academics and policymakers have been convinced that market mechanisms were better than government planners at identifying promising technologies. There are examples of failures of central planning that reinforce these beliefs, and for several decades, the economic performance of the American economy also justified that faith.

There are reasons to challenge this ideology now. First is the simple fact that many American industries are having great trouble in world competition, and some of the ablest international competitors assuredly do not have freer markets or lighter government involvement in supporting industrial technologies than the United States does. The governments of many European nations, Japan, Korea, and Taiwan, have all actively promoted manufacturing technology acquisition, development, and diffusion; and while they have had their failures, they have had many outstanding successes. This is not proof, of course. Many other nations with less than admirable economic performance have also supported technology development and diffusion.

America's own history provides examples of successful commercial industries building on abundant government support of technology. Some of this has been an indirect effect; the Department of Defense's support of the early development of semiconductors and computers paved the way for substantial investments in commercial technologies by the private sector. But the United States has sometimes been willing to make exceptions to the tenet that direct government support should be limit mostly to basic research and national security. The development of a U.S. civilian aircraft industry can be linked directly to government-supported research on airframe and propulsion technologies in the early part of the century. This support was justified on patriotic grounds, and was not drawn so narrowly as to include only military security needs. Government support of agricultural technology through the land grant universities and the Cooperative Extension Service has been a key to the rapid productivity growth of American agriculture in the 20th century. Government support of the space program from the 1950s onward rested as much on national pride as on defense needs, and has had some important commercial payoffs.

Still, the argument most often put forward for Federal support of technology development remains rooted in national security. The Department of Defense depends on the civilian microelectronics and other high technology industries of its procurement needs. This was a key factor in the consideration of whether and how much to support Sematech, high-temperature superconductivity, and lately, high-definition television. But the idea that only the direct, immediate needs of the military justify government support of technology development is wearing thin. The time is ripe for reopening the question of how the Federal government could support development of civilian industrial technology proactively—i.e., before the industry is so weakened that national security is threatened.

Many people still reject this strategy. They argue that selective government support of key technologies or industrial sectors amounts to

"picking winners" and that government bureaucrats are ill-equipped to make these choices. This argument rests mostly on politics. The American political system is too subject to manipulation by special interests, it is argued, to make rational choices among all the potential industries and technologies that might merit government support. This is a forceful argument, one to be taken seriously. Another pillar of the argument is the simple claim that the market, with its imperfections, is better than government interference.

The other side has a powerful justification as well. That is, that some technologies are so risky or involve such large investments over the long term that little or no development will be undertaken unless society, which stands to benefit, shares the risk of development. In the U.S. financial environment, with its burdensome penalties on long-term investment, the argument takes on special force.

The debate over "picking winners" has resolved little. Those who argue that government cannot make consistently rational choices can point to failures, such as the money poured into the Synfuels Corporation in the early 1980s to make wood-based, coal-based, and shale-based substitutes for petroleum. Japanese policies have not been invariably successful either. Examples of projects that did not achieve their initial objectives include efforts to jump-start biotechnology development, the fifth-generation computer project, and entry in the civilian air transport industry.

There have been some notable successes as well. U.S. Government support for aircraft technology development, through both civilian and military agencies, and agriculture are examples. These industries, which have had much greater government support than most, are advanced technologically and successful internationally. Both can boast large trade surpluses. Successes in Japan encompass the major industries on which that nation's astounding postwar economic achievements rest—first, steel, chemicals, and shipbuilding; then automobiles; and now microelectronics, computers, and telecommunications.

More to the point, the argument cannot (and should not) be resolved by counting up successes and failures. Any sustained effort to support new technology development will include some failures, and some industries might succeed more in spite of government support than because of it. The fact is, the U.S. Government is increasingly being asked to support technology development, and it is becoming ever more obvious that the reason is to build civilian industrial competitiveness. It is possible to take the best from the "picking winners" debate by focusing on how to design institutions that are open to counsel from and collaboration with industry and other interests, but avoid becoming their captives. Another lesson is that a crisis is a poor crucible for making such decisions. The failure of the Synfuels project can be traced largely to the atmosphere of crisis in which it was born.

**A Civilian Technology Agency**

Efforts to support industrial technology will require commitment and money. Both have their limits. Public initiatives to help private manufacturing improve its performance cannot afford to plunge into repairing and developing every industry and technology. Yet the Federal Government has no institutional ability to discriminate between technologies and industries that are most promising for the Nation's economic future, and those that have some appeal but are less important. While the U.S. Government has acted to support certain key technologies, the responses to declining competitiveness have been ad hoc, and are usually justified by the seriousness of potential losses in military security. If Congress wishes to consider ways of responding to pleas for support of technology toward the goal of economic security, one option is to create a civilian technology agency.

One approach is to build on existing institutions. NIST's Advanced Technology Program, created in the 1988 trade act and funded for the

first time in fiscal year 1990, at $10 million has the potential to develop into a CTA. A bill that passed the Senate in 1989 authorized $100 million for the program to support industry-led joint R&D in economically critical technologies. Five such technologies were spelled out in the Act.

Other bills in both the 100th and the 101st Congress proposed the creation of a Civilian Technology Agency (CTA) within a new Department of Industry and Technology taking the place of the Department of Commerce. The agency would make grants or cooperative agreements with private performers of R&D on high-risk projects that could have exceptional value to the civilian economy. The closest analogy among existing agencies to a CTA is the Defense Advanced Research Projects Agency, or DARPA, which supports development in technologies and industries considered critical to the nation's defense. This small agency (staff of 150, funding of nearly $2 billion per year) has gained a reputation for placing intelligent bets in serving U.S. military technology needs. It makes long-term commitments that have added up to decades for some of its projects. DARPA has at times interpreted its mission broadly, supporting technology development that will benefit the commercial sector because the military depends on that sector. A CTA could learn a good deal from DARPA's experience on how to evaluate the potential benefits and risks of investments in new technology, and how to balance the pressures of industrial and parochial interests in making such decisions. The CTA might be subject to greater special-interest pressures, but the difference is likely to be one of degree rather than kind.

In some ways, a CTA would be quite different from DARPA. Most important, a CTA would interact closely with industry in choosing what technologies to support and designing the R&D projects. Until recently, DARPA did not fund projects jointly with industry; a CTA would probably finance most of its projects with contributions from industry that are at least equal to if not greater than the government share. This *joint funding is essential* as assurance that industry is genuinely committed that and the projects are really promising commercially, in the opinion of industry. Thus, the problem of government's "picking winners" would be greatly diminished.

Where in the Federal bureaucracy the CTA is placed may not matter very much. There are some advantages to its being an independent agency like the National Science Foundation. With the right mandate, independent agencies, even small ones, can wield influence beyond what their size would indicate. (NSF is funded at less than $2 billion per year.) However, DARPA demonstrates that a small agency within an enormous bureaucracy can be effective and powerful. With the right design, sufficient funds, top-notch staff, and a strong mandate from Congress, a CTA could probably function well either within the Department of Commerce (or a successor department) or independently.

Other issues are more important to a CTA's performance. Judging by the difference between DARPA's performance and the record of other DoD technology development and acquisition, it is clear that the agency should not be constrained by detailed rules and procedures. Giving the agency staff a large degree of freedom and responsibility could help to attract and keep technically first-rate people, which is increasingly difficult as salaries for scientists and engineers rise faster than government salaries.

One of CTA's first tasks would be to develop guidelines for the selection of industries or technologies to consider for support. Here, much can be learned from the debates over whether to support specific technologies or projects like HDTV, superconductivity, and Sematech. There is an obvious preference for industries that are high-tech, provide well-paid jobs, and have high growth potential. In addition, CTA would need to consider entire technological systems, not just particular technologies. For example, if it chose some semiconductor

*technologies, it would have to be sensitive to* R&D needs throughout the system, starting with improved materials, and continuing through things like lithography for etching chips, automated techniques for packaging, and so on. CTA could also look for technologies important to more than one application or industry downstream.

One of the surest ways to doom the effort would be to subject a CTA to unrealistic expectations. If CTA is expected to make strategic choices of high-risk technologies, it would have to be given time for its investments to play out, and some leeway to make less than perfect choices. The ability to make multi-year funding could also be critical. As it is, American business regards government support as volatile and undependable. The fact that Silicon Valley companies took very seriously recent rumors that the Administration proposed to abandon funding for Sematech illustrates the point. If the agency is to succeed at pushing technology, it would need to provide steady support for several years to many different technologies. Even then, it should not be expected to turn American industrial competitiveness around singlehandedly. Coordinated support in other policy areas like trade and macroeconomic policy will be needed to do that.

**NOTE: Copies of the report "Making Things Better: Competing in Manufacturing" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325, GPO stock No. 052-003-01178-6.**

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The CHAIRMAN. Thank you. I appreciate the summary, and of course it will be crucial to read and study the full text of your report.

Senator D'Amato, did you have an opening comment you would like to make at this point?

Senator D'AMATO. Yes. Mr. Chairman, in the interest of time, I would like to be able to submit this statement as if read in its entirety.

The CHAIRMAN. Without objection.

Senator D'AMATO. Thank you.

## OPENING STATEMENT OF SENATOR D'AMATO

Mr. Chairman, the reports which have been delivered today by the Office of Technology Assessment contain many important observations and suggestions. The OTA report placed undue emphasis on the areas in which the Government should play a role in making U.S. manufacturing more competitive. In particular, I am not yet convinced that the Government does more good than harm in its attempts to select and promote new technologies. While it is clear that Government and business should not be adversaries, Government attempts at assisting certain industries bring to mind the warning of Mark Twain: one's enemies can do considerable harm, but it takes a well-meaning friend to come along and really finish the job.

There is one part of this report that I agree with wholeheartedly and is the most important issue facing this committee. America's financial climate is a disadvantage to America's manufacturing industry. The high cost of capital, resulting from low savings and high Government borrowing has a direct adverse impact on productivity and competitiveness of America's exports. The disincentives in the Federal tax code against savings and investment—double taxation of dividends, taxation of interest on savings and taxation of capital gains—are matters for governmental concern. And of course the Federal deficit must be reduced. But most important to us, our antiquated legal and regulatory system which inhibits the financial services industry's efficient delivery of capital to the manufacturing sector needs overhaul. This will be a difficult task but the time is at hand.

Mr. Chairman, one issue that was not addressed in the OTA report is infrastructure. Just as low private investment makes particular industries less productive and less competitive, low *public* investment in infrastructure reduces the productivity of almost all industries in both the manufacturing and services sectors. Examination of competitiveness should include a broad look at the impact of public capital investment on the productivity of American firms. We should begin with a close look at the use of capital budgeting so that we consider Federal infrastructure investments in their proper light.

The CHAIRMAN. Let me take you back to the last point you were making, Dr. Gibbons, and that is take us the next step in terms of how the support for research and development of the commercially important technologies might be done.

Now you talk in terms of a sort of bolder institutional step in that direction. Can you fill that idea out a little more and explain some of the things you might envision that would fall into a category of sort of being up at the top of the list that would warrant that kind of focus?

Mr. GIBBONS. Mr. Chairman, we would be happy to respond to that. If I might, may I ask the project director, Dr. Gorte, to speak to that question.

The CHAIRMAN. By all means.

Ms. GORTE. There are many approaches to creating an institution that can support research and development for commercially promising but very risky technologies. A couple of them are before the Congress now and have been proposed in earlier Congresses.

One is the creation of a Civilian Technology Agency, and another is to give NIST, the National Institute of Standards and Technology, additional money to perform the same functions.

We think the Civilian Technology Agency is very promising from the standpoint of supporting technologies that a lot of companies find prohibitively expensive, and might involve betting the company. High technology in particular is increasingly requiring investments of hundreds of millions or billions of dollars, and even our largest companies, especially in America's hostile financial environment, are unable to make many, if any, of those kinds of investments. The kind of partnership that we thought Government could enter into with industry in investing in those technologies is important.

For a long time the debate focused on what technologies, and many people said it would be really difficult to figure out what they are because you have so many things competing for your attention. Yet if you look around the world you can find that every major advanced country and a lot of the fast developing ones know what they are, and we know what they are. We know that they are in the areas of microelectronics and computers.

The CHAIRMAN. I want to slow you down here. Microelectronics, computers——

Ms. GORTE. Aerospace, biotechnology and other kinds of chemicals and pharmaceuticals.

The CHAIRMAN. Chemicals and pharmaceuticals of the more exotic type I take it?

Ms. GORTE. Yes, in general. What did I miss? Telecommunications, advanced materials and advanced machining—metal bashing, we call it. Those are the ones that the European Community, the Japanese, the Koreans and the Taiwanese have all supported.

The CHAIRMAN. You mean that the governments have supported the private sector in those countries to really drive the rate of technological advancement along faster in those areas?

Ms. GORTE. Quite right, exactly. What they have in common is that they are knowledge intensive, they are R&D intensive and they require large investments that are risky at the beginning. Once some of the technical problems are solved or you can see the way clear to solving some of the technical problems, industrial investment flows into those areas.

If you look at them retrospectively, it looks as though Government's role was small, but as a catalyst it's quite important.

The CHAIRMAN. I noticed that in an article on January 23 in the New York Times it was noted that for the first time in 14 years spending on corporate research and development in the United States has not even kept pace with inflation raising concerns that the Nation is falling further behind in terms of attempting to hold its competitive edge in high technology.

Also, that article noted that for 1987 the growth of research and development spending among Japanese companies was more than three times that for American companies.

Now I'm wondering has there been a drop-off of research and development spending by American corporations and, if so, what is causing that. Obviously, I'm also interested in any reflections you can give us on the consequences of what happens if that continues for any long length of time.

Mr. GIBBONS. Let me make a quick response, and again I ask Dr. Gorte to fill in. Clearly the cost of doing research and development in terms of the cost of money involved in the United States is greater than that in Japan. Also the patience of investment capital besides its interest rate is much higher.

The Japanese focus on market share and other things cause them to keep an attention to the long term, whereas we are drawn for a variety of reasons that I mentioned earlier to the shorter-term conditions. So if your horizon is much closer in time, you're naturally less inclined to invest in some of the long-term, high-payout activities.

Ms. GORTE. For a long time in the United States, when we first began talking about competitiveness problems and long before very many people accepted that we had a competitiveness problem in manufacturing, we were accustomed to say we do the best R&D in the world and we do the most R&D in the world.

The actual fall in the amount of company financed R&D that happened, I believe, last year, marked the first decline in recent history, and we are starting to become concerned that R&D is going to be a problem in the future. You have to keep the pipeline filled, and you have to keep new ideas coming along and being worked on in order to have something to commercialize later 5 to 10 years from now.

I think Jack is absolutely right that the financial environment of the United States has made it very difficult—in fact, increasingly difficult—for companies to afford the heavy investments in research and development that need to be made in order to support high-tech systems.

The CHAIRMAN. Ms. Gillman, let me ask you, you've been working on this for a period of time, if you were to single out one aspect of this that really has struck you most powerfully in this complex multifaceted story, what would be the thing that stands out most and that you have the strongest feeling that we need to move on?

Ms. GILLMAN. I think that a partnership between Government and industry to share the risk in very long-term uncertain investments is the thing that seems most lacking in our economy compared with our best competitors, particularly in view of the fact that our financial environment is hostile to these long-term investments, much more so than the financial environment in Germany and Japan, which are our ablest competitors, not to speak of the

Asian rim companies which are coming up. That is the biggest hole in our economy I think, the lack of Government sharing the risk with industry.

The CHAIRMAN. I'm about to yield to Senator Heinz. I agree with that, and that issue is such a powerfully important one in this new global economy, and yet we have great difficulty debating that in the United States. We somehow think that if we get into a partnership with business and Government and labor that somehow or another that cuts against the free enterprise system and our long-standing values.

I think it's nonsense when you look at it, and in fact there are areas where we've actually had the most powerful working models of such partnerships. Take the space program, for example, where you've had an absolute combination of business and Government and labor putting together a team America approach. It has been phenomenally successful in terms of just the sheer speed of the advance that we have made taking Americans to the surface of the moon and bringing them safely back to earth, and any number of other things that we have done. All of that was a manifestation of that kind of consortium thinking and effort, the idea that the country can function in a unitized sort of single-minded way on a very complex project. Although that is a contemporary example, as current as the fact that we launched another space shuttle last night, and we have a very ambitious launch schedule ahead of us now, there are many other examples that may be cited.

So I appreciate the point that you make. I don't quite know how we bring the doubters along who think somehow that there is a risk to the country if we work together. I mean there are people out there who really get cold chills at the notion of America really working together as a team.

Let me yield to Senator Heinz.

Senator HEINZ. I guess if I had to summarize this OTA report, "Making Things Better," what I would say is you have looked at the three prerequisites for a successfully competitive economy which economists have traditionally have told us are labor, capital and management—the three basic inputs to get anything out. You've said with respect to labor, which is normally a function of motivation, education, and skill that we've got real problems with respect to education and skills in the work force. So that's one of three possible strikes against us to begin with.

Second, on capital, you've identified that our cost of capital is differentially high. If we were great in everything else and our cost of capital were differentially high, one might ask how can we ever win in the international competitive arena.

You've touched only a little bit on management. I want to ask you two brief questions about that equation. One has to do with the charts you have, figure 13 and figure 12. Figure 12 is percent of GDP spent on education for grades K through 12 where the United States is third from last. We spent about 4 percent and other countries spend as high as 7 percent. The other chart, spending for education per pupil, appears to show the United States doing a lot better.

I'm a little puzzled as to why we spent a lot per pupil. I know that the statistics pretend to show that we have a higher GDP per

capita than most other countries. Indeed OTA has been very helpful in preparing a series of charts for us, and at least one very unusual chart, Ms. Gorte, that shows this very substantial lead.

Now my problem with the data on of GDP per capita is that to look at it, the United States is up here and everybody else is down there, and they just seem to go more or less parallel forever irrespective of what has happened since 1984 to exchange rates.

Now what I always learned, or what little I learned, is that what the dollar in your pocket can buy is what counts and not the number of dollars, and it seems to me we have got a statistical problem of some kind in the way we analyze that may cause us to slightly mislead ourselves. I'm not saying you're misleading us, but I think there are some statistical problems with our analysis that if we corrected for them we might find that our real spending for education per pupil is not as good as it looks.

Is that possible or not, and who wants to answer that?

Mr. GIBBONS. I'll ask Ms. Gillman to respond to that.

Ms. GILLMAN. When you look at the spending per pupil, that's in dollars. You have to translate other currencies into dollars at international exchange rates.

Senator HEINZ. That's not what the Department of Labor, which is the source of a lot of your statistics, has done.

Ms. GILLMAN. We have used the purchasing power parity exchange rate from the OECD which is supposed to mitigate the up-and-down changes in market exchange rates. Nevertheless, those figures are from 1985, and at that time the dollar was at its historic high. So figures from that year overstate the amount that we spend per pupil, even though we have mitigated somewhat the effect of the high dollar of 1985.

Senator HEINZ. Maybe you could prevail upon someone to give us the right numbers.

Ms. GILLMAN. A second thing is that there really is a conceptual reason why it's important to think about the proportion of GDP that we spend on education as well as absolute amounts of dollars per pupil. In a poorer country, one that has a lower standard of living but spends more of its income on education such as Japan, education gets much more attention in that society proportionately than it does in ours. Teachers are paid more in relation to engineers, and I won't say lawyers because they have hardly any lawyers in Japan, but teachers are paid very well in relation to other professions.

In our country that 4 percent of GDP spent on education, compared to the 7 percent in Sweden or the 5 percent in Japan, indicates that we reward our teachers less and that in this rich country we devote less of our resources to education.

I think that both measures are meaningful, but the one on spending per pupil is definitely overstated because of the high 1985 dollar.

Senator HEINZ. Because the dollar was so strong at that time.

Ms. GILLMAN. Right.

Senator HEINZ. Very good, and I'm glad you made that point.

On capital in general, we overtax equity compared to other forms of capital in our country compared to other countries. Some people have said well, the way we ought to deal with the problem, the re-

lated problem of short-term focus of equity investment, is to make it less attractive to hold or issue debt by taxing interest as it's outlaid or as it's incomed. My problem with that prescription is that that simply raises the total cost of capital. Is that correct?

Mr. GIBBONS. Yes. Dr. Gorte would like to respond to that.

Senator HEINZ. I'm trying to get to a question and I'm going to run out of time. So I apologize. One of the arguments for the President's capital gains proposal is that it will lower the cost of capital. I don't know by how much, and that's material, but is that true that the President's capital gains proposal will at the margin perhaps lower the cost of capital?

Ms. GORTE. I'm sorry to admit to you, Senator, that we didn't look at it in that light.

Senator HEINZ. All right. Let me get to where I really wanted to get to anyway. Did you all look at whether length of holding period was important?

Mr. GIBBONS. Length of holding period is important and it varies quite substantially, although the numbers are hard to get, between institutional holdings, which from some reports are of the order of 5 or 6 months holding period, versus individual investors in which the average holding period is 2 years or so.

One reason for this of course is that the institutional holders don't endure tax consequences of trading and that policy in effect helps encourage the churning of these accounts, and that in turn makes it difficult for a manager to make long term investment decisions.

Senator HEINZ. Frankly, I'm a little skeptical of the notion that in effect taxing profits from trading necessarily reduces trading. If you make less every time you trade you may trade more. The law of unintended consequences is one I have great respect for.

Where I was going with my line of questioning, though, was this. If we had a choice, and we may very well have this choice, between a cut in the capital gains rate, which applies to everything irrespective of length of holding period, and the alternative of indexing based on length of holding period, and there are a lot of ways to do it, which would be more pro competitive in your judgment? Would indexing based on length of holding period and at least at the minimum taking out the tax on inflation for people who are willing to hold longer be more procompetitive than the President's proposal?

Mr. GIBBONS. It seems to me that clearly if indexing were the case, one at least would be encouraged to think about the time of holding when one decided to sell or to invest. It does nudge you in the direction of thinking in the longer term.

Senator HEINZ. So of the two, that is more likely to have pro competitive effects, would you agree?

Ms. GORTE. I just wanted to see if I could answer your question in a slightly different way. The biggest problem for American companies is the cost of capital. The fast turnover sparked by the takeover mania of the 1980's is an additional problem, but by no means as large as the high cost of capital.

So the first line of pro competitive action to take is to reduce the cost of capital. We haven't looked at your specific question, but whichever of those is more likely to reduce the cost of capital directly is probably going to have the greatest effect.

Senator HEINZ. Now to do that is a subject for endless hearings.

Mr. Chairman, you've been very kind. I have to go down to the Finance Committee for the HHS budget, but I do intend to return. I thank my chairman.

The CHAIRMAN. Thank you, Senator Heinz. Senator Heinz and I both serve on the Finance Committee and are otherwise required to be there this morning on other matters, but it also gives us the chance to pursue these tax issues at the place where we change the tax law. So it's important to pursue these things. We both have taken more time.

So, Senator Bryan, I want you to take a longer period of time as well.

Senator BRYAN. Thank you very much, Mr. Chairman.

I'm new to the Congress. This is my 14th month here, but virtually every report by those who have studied the problem and have looked at the difficulties which this country faces and the increasingly competitive global climate generally reach the same conclusions that you have, that we've got to do something about the national debt.

The figures that I had provided to me the other day is that this year when one takes into account all the money that we raid from the Trust Fund, the Social Security, the Aviation, the Highway Trust Fund and others, that we will add $332 billion of new debt this year. So I guess without being a cynic, I'm not optimistic that we're going to make much progress in that area.

Let me ask you some questions about tax because the models that are always called to our attention, the Japanese and the West German models are the ones that are seemingly in this competitive climate doing very, very well. The Germans, for example, now lead not only us but the Japanese in terms of world exports, and their economy is booming.

What are the fundamental differences in terms of the way the tax codes in Japan and West Germany treat capital gains, what are the general brackets in terms of rates on ordinary income, and I don't mean a detailed description, but just tell me in general how their tax systems compare with our own.

Mr. GIBBONS. Let me ask Dr. Gorte to respond to that.

Senator BRYAN. Thank you, Mr. Gibbons.

Ms. GORTE. We have looked at a great deal more at Japan than West Germany. So I will tailor my answer to what I know about Japan.

Senator BRYAN. Please.

Ms. GORTE. Right now the Japanese corporate tax rate is nominally higher than the American corporate tax rate. When we lowered the corporate tax rate with ERTA, the overall tax rate became lower. However, the Japanese tax system in many ways encourages investment in manufacturing, in capital and in R&D, and if you looked, as we do in our charts, at the cost of specific investments in equipment, in factories and in research and development, it turns out that the cost of capital for those activities that are investments in future productivity growth are very much lower, sometimes on the order of 50 percent lower.

So it's a hard thing to untangle. For example, in Japan you can depreciate certain kinds of major plants in 5 years, and in America that would be 40 years. They have very generous depreciation laws.

Senator BRYAN. The depreciation allowance is one category. Do they have anything comparable to our old investment tax credit? Is that available?

Ms. GORTE. There are a variety of things that are both permanent and special. For example, in 1984 I believe there was a provision made for people to write off the cost of CNC machine tools very fast. That's still in place. It was called the Mechatronic Era, the beginning of the Mechatronic Era.

Senator BRYAN. So they have some ad hoc special rates of depreciation schedules to encourage people.

Ms. GORTE. Quite right.

Senator BRYAN. How about their ordinary income rates, what are the parameters and what do they have as their top rate?

Ms. GORTE. I'm sorry, Senator, I don't know.

Senator BRYAN. Do you know whether it's higher or lower than ours?

Ms. GORTE. Do you mean for individuals?

Senator BRYAN. Yes, for individuals.

Ms. GORTE. No, I don't, I'm sorry. I can find out.

The CHAIRMAN. If you will yield on that point. I think on any issue like that which you feel is relevant to sort of filling out the knowledge that we need to have that it's entirely appropriate to ask that something like that be gotten, and I'm sure they will be cooperative.

So in any point at which they may not have been able to take their study that you think it ought to go in the next phase, I would like you to request that for the record with my support and we'll get it.

Senator BRYAN. Mr. Chairman, I thank you. I know that there are a lot of people that continue to make work for you, but I do think if we're talking about a comparison of business and investment climate and I reach the same conclusion that you do, I think that's highly relevant and one of the reasons why we're placed at a disadvantage, but it would be helpful for us to take the two models that seem to invite the most favorable comparison, West Germany and Japan, and analyze those differences in the sense you cited many examples, and I don't ask you to recite all of those this morning, but clearly the depreciation schedule is one in which there are some favorable considerations.

What are the tax rates for individuals and how do those compare, what provisions, if any, do they provide for capital gains treatment and what kind of differential is present, what kind of special consideration, if any, is given to dividends on the part of stockholders, do we have in Japan and German a system which in effect the dividend is taxed twice, one in the form of a corporate income tax and secondarily when it's distributed to the recipient as a dividend? I think that would be helpful, and I don't mean to take a lot of your time now to speculate on that, but with the chairman's concurrence, I think that would be helpful for us to understand.

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I happen to be of the view that the 1986 Tax Code takes us in absolutely the wrong direction, but maybe that's not a basis upon which Japan and Germany does better in terms of investment and encouragement.

Mr. GIBBONS. We would be pleased to respond to your question, Senator Bryan. We will try to remind you of some of the factors that go behind the bottom line in our charts which would show the difference in costs of capital for those two countries compared to the United States.

Senator BRYAN. I would appreciate that.

Let me ask you, and I always come back to this when people like yourself with the kind of erudition that you bring——

The CHAIRMAN. Would you yield for just one more second at that point?

Senator BRYAN. I certainly will.

The CHAIRMAN. I think what you've just asked for is very important. It's the next step that leads logically from the work that you've done, and I think Senator Bryan has teed up the comparisons that we want with Germany and with Japan particularly.

In addition to the things that he has asked for, I would like us to be able to discuss other things. I would like to know, in addition, whether the role of the institutional investor seems to be the kind of factor there that you alluded to earlier that it has become here where the trading horizons are different and the rise of the institutional investor has changed attitudes or at least practices in investment period impacts and so forth.

I'm even wondering if things like leverage buyouts, for example, can be seen and whether that plays through their system the way it has through ours or not, but things of that kind I think you should take an encompassing view of the factors that sort of make up all of the cross-cuts here.

Senator BRYAN. Thank you very much, Mr. Chairman.

I also share the chairman's frustration that somehow the notion that if Government participates that there is a sinister consequence that attaches to that.

If I recall correctly, when Samuel F.B. Morris came with the concept of the telegraph he asked the Congress to appropriate money to build the line from Washington to Baltimore when it was first tried. Am I correct in that? That's my recollection.

Mr. GIBBONS. That's my memory, too, Senator.

Senator BRYAN. Yes. So that goes back 150 years. So I mean it wasn't so radical then, and I think most of us would recognize that that was a substantial improvement. It did put the Pony Express out of business, as you will recall in 16 months. So it was a technological breakthrough in that era. But other countries, Japan and West Germany in particular use that as a successful model from what I'm gathering from your testimony which you prepared and your report.

How do they make the determination as to which types of investment and participation Government ought to participate with the private sector? How is that done?

Dr. Gorte, maybe you have the answer. We know they do it. Tell us how they make the judgment as to what to do.

Ms. GORTE. Well, I have two things to say about that.

Senator BRYAN. Please.

Ms. GORTE. First, in Japan, in particular, and now increasingly in Europe, with the EC-92 R&D programs like JESSI, and RACE, and BRITE, and EUREKA, and all of the wonderful other acronyms that they have, it's with a lot of consultation with industry leaders and other experts. In other words, there is a constant flow of people and ideas back and forth to try and discuss what those investments are and where the most promising investments are.

There is conflict there as well. I mean everybody doesn't agree, and that will happen in America, too, and they don't always make the right choices. You can't if you're trying to make choices about what is going to be the cutting edge in the future. You're going to have some failures.

But there is consultation and reassessment at regular points and, as Jack put it, there is no silver bullet. That's how it's done; you have to keep assessing it in real time.

Japan is famous for this. We call it consensus building, and I don't think that we can replicate their system. But we do know how to negotiate, and we do know how to work together in America. We've sort of forgotten that in the last decade.

Senator BRYAN. Do they have a particular agency within the Federal establishment in either Japan or Germany that in effect takes all of this, and you're right, there is certainly going to be differences of opinion just as there are in this country as to where we ought to put our dollars, but how is it sorted out and in effect the policy-makers, the Prime Minister, the Chancellor, the Bundesdogue, the Diet, how do they in effect say look, we're going to appropriate the money in the following five areas and not in another five?

Ms. GORTE. In Japan it's not so much the Diet. It's the executive branch, it's the civil servants that make the decisions. We've commonly identified MITI, as the linchpin, and it's quite true that MITI is responsible for a lot of the guidance. But you'll find that every Ministry in the Japanese Government, whatever its constituency is, will be backing and forthing with the people that are in its constituency trying to figure out what the most promising investments are. The Ministry of Finance does it, as does the Ministry of Posts and Telecommunications, the Ministry of Education in its influence on the R&D budget, and the Space Agency, all of them.

Senator BRYAN. I know as an aside, and I've got one last question if the chairman will indulge me.

The CHAIRMAN. Please go right ahead.

Senator BRYAN. Thank you very much, Mr. Chairman.

The comment that I had to make, which I will invite a question and then my final question if I may. In listing those areas in which we ought to be participating at least as a catalyst with the private sector for technology investment, notable by its absence was the superconductor-supercolider that we're spending $6 or $7 billion. Was that by inadvertence or do you suggest that perhaps we ought not to be spending the $7 billion? I serve on the Commerce Committee and I can tell you that every constituency has got its own nitch that they are urging us to participate in. The superconductor-supercolider, is that something that perhaps ought not to be in the

top five, or do you think that's something we ought to be spending that kind of money on?

Mr. GIBBONS. If I might make a brief response to that, Senator.

Senator BRYAN. Sure.

Mr. GIBBONS. The superconductor-supercolider is an effort on the frontiers of science itself in very basic research, and to that extent we don't think of that as a venture in civilian technology development, but rather one that compliments with an "e" that process.

The SSC not only advances the state of knowledge, but it also challenges the development of technology just as the space program and the defense program do, and it pulls along technology development associated with those fundamental investigations. But we see that as a different kind of activity, namely, filling our warehouse with fundamental information, and hopefully like, for instance, the human geno project, something that pulls technology along with it to help it answer the questions.

Senator BRYAN. Well, thank you very much.

My final question is one would think that the National Association of Manufactures and people who are literally on the factory floor, people who see this firsthand what you are reporting to us would be leading the crusade and mounting the charge and getting the nation energized. I don't sense any of that occurring. Is there a fundamental difference of opinion? Do they note share these concerns, or do they just feel that that's not their role, or maybe they are talking and some of us aren't listening or not hearing.

Dr. Gorte.

Ms. GORTE. Two of the people from industry are here this morning and you can ask them yourselves. We have been hearing a lot more. There is a consensus developing in America that we need to have a partnership, that we need to be doing different things and bold things in order to improve technology diffusion and development in manufacturing, and it's coming from industry. We are hearing this from NAM, we're hearing it from the National Center for Manufacturing Sciences, we're hearing it from individual companies and decision leaders in industry, CEO's and so forth. And that's becoming more and more consistent in our view. We talk with them all the time and we're seeing more and more of that. So I think it's happening. You know, it's hard to see at the beginning.

Senator BRYAN. Maybe we'll end my questioning on a positive and upbeat note.

Thank you very much, Dr. Gorte.

Mr. Chairman, thank you very much for your special indulgence in terms of some time for my questions.

The CHAIRMAN. Well, I'm very much interested in the questions you've raised, and we'll follow through with what you've asked for.

I have a couple of questions for the record, and I'm going to just state them in passing, and then Senator Heinz has a question and then, Senator Bryan, depending upon your wish, I think we'll go to our next witnesses who we are very anxious to hear.

I want to make the observation with respect to another news story that ran recently on February 22 of this year. The Wall Street Journal reported that the Bush administration had agreed to support legislation easing antitrust restrictions on joint production efforts by U.S. companies. But then it was reported that

Budget Director Darman and Council of Economic Advisers Chairman Boskin agreed to go along with the proposal only after it was stripped of measures to encourage financing of joint production efforts because they were concerned that if that were part of it it might amount of an "industrial policy." It sort of relates to this broader question as to where we ought to have nervousness and where shouldn't we have nervousness about these things.

I must say I'm concerned when I see that because I think we may have a blind spot in some of the thinking about an executive branch side about the degree to foster combination efforts both in terms of pulling diverse parties together, but also coming up with the financing required to really move things because the country has got to make a surge, and every measure that we have with respect to how the international economy is working and how we're functioning comparatively and competitively shows that we need the surge.

So here you're coming in and saying that you do believe there is a role for partial Government funding of joint production projects. You've clearly stated that view. You have no philosophic I would assume or political bias one way or the other. You're the Office of Technology Assessment and you've come in here to try to give us a bottom notion of what it takes to move faster vis-a-vis the rest of the world. So I take it that you think that we do have to give some consideration at least to how these things are financed to make sure they happen. Is that a fair summary of your view?

Mr. GIBBONS. In our study we didn't go deeply into the issue of joint production, but I do recall a quote from Abraham Lincoln who spoke about the stormy present cannot be resolved or solved by the quiet dogmas of the past, and I do think we have to think in new ways and perhaps break some of our older traditions albeit carefully. But one simply can't keep going the way we've going unless we want to do as the Chinese say, end up where we're headed.

The CHAIRMAN. You know, it's so interesting, and I was just about to yield to Senator Heinz, but Senator Heinz and I both have spent some time up at the Harvard Business School at different times, and we both represent industrial States, although every State today has some industrial and manufacturing component to it. But certainly Pennsylvania and Michigan are two of the heavyweight States. So we've had to cope. In his case the steel industry has been largely centered in his State, and the auto industry largely centered in mine, and of course a lot that radiates out from that, but we've had to deal within the context of our State situations with the monumental changes that have come about and the impacts because of this shift in our relative position on a global scale.

These are real questions because it's the wealth of this country and it's our future living standard and our job base that is at stake. So these aren't questions to be decided by idealogues. I want some people that look at the bottom line in terms of what we are yielding in terms of the net production of this country, our productivity rates, what are we yielding in the way of our overall output and how is it making its way through to our people.

That's really the key, and if your goal is to beef that up and then you start looking at the things that it takes on a global

basis to drive it ahead at a faster rate. And I sure hope that we're not going to get into a situation where you've got people that are out there who find it very difficult to think in terms of new arrangements because it violates some personally held notion.

I worry about that because we've got a big gap to close, and the gap is widening today. It's not closing on its own.

Senator Heinz.

Senator HEINZ. Mr. Chairman, thank you.

Your comments made me think of an article I was just reading, a prepublication article for the Harvard Business Review by Mike Porter on which I have been invited to submit a comment to appear along with its publication. Mike Porter is one of the most thoughtful people I know with the Business School who studies competitiveness in the real world.

One of his conclusions has to do with antitrust law, and, interestingly, it's different from the conventional wisdom, which argues you need to relax it in order to match the competition.

What I would like to do is send it to one of you for your comment. Maybe that will make my job easier because it's really quite provocative. He studied actual industry situations in other countries, and it presents a challenge to some of the things we've been talking about.

The question, however, I wanted to pose is that the other way of summing up what you've said today is that the formula for economic success of a country, labor plus capital plus management, is an old, outdated quiet dogma of the past, and there is one other term that needs to be added to the equation, which is Government support or cooperativeness.

Now most economists will tell you that whatever Government gives to somebody it takes away from somebody else, and indeed that's true. Even when we spend more money than we take in, we take it away in the form of debt from somebody else. Those laws of economics still apply even to Congress.

The question I've got is how do you answer the macroeconomists who say because you only can output to somebody what you take away from somebody else that therefore it is a zero sum gain and all you are doing is redistributing, and whether you mean to or not, you are picking winners or losers. How can you prove that there is added value as opposed to simply redistribution?

Mr. GIBBONS. Well, I'm going to hazard a brief response and then ask a card-carrying economist to respond to you.

First of all, you know the old land labor capital idea has evolved to capital labor management. I prefer to think of it in terms of labor, capital and technology, and technology is the thing that drives from the traditional American public sector's involvement in research and the outpourings of research which turn into technology.

I think in a sense we're not so much speaking of reaching out and taking more money away from some other productive activity. There are a lot of things one can do with the present resources or influence that the Federal Government has, and let me give you one small example.

We presently massively subsidize the flow of investment capital into commercial and residential housing buildings. They may or

may not be the most effective way for our nation to move in the future. Some of that subsidy there is de facto, a penalty to investment in equipment in factories and other things that make for production. Even within a zero sum gain there are shifts that can be made that end up as a productive result.

Ms. GORTE. The notion of redistribution and the idea that if you take from industry "A" or person "A" and give it to person "B" all you are doing is redistributing and that is not necessarily going to yield you any positive benefits rests on the presumption that person "A" or industry "A" and industry "B" have the same rate of growth and the same rate of spillover to society, and that's not true. Not every game in economics is zero sum.

By suggesting that Government take resources from society and provide them differentially to activities that have high spillovers and high benefits to society if the problems are solved, what we are saying is that we can raise the overall rate of growth of the economy.

Senator HEINZ. Let me correct you in this sense.

Ms. GORTE. Please.

Senator HEINZ. I don't mean you said anything wrong. But if that's all we say, then no one is going to really understand what is going on and why the macroeconomics of the past is wrong.

The reason the old economics are wrong is they don't take into account two really critical variables, exit costs and entry costs. Exit costs are something that Don Riegle and I are very familiar with I'm afraid.

The entry costs are something that nobody has really studied much, but I think it's probably fair to say that 10 years ago we knew a lot about exit costs, those of us who lived in industrially vulnerable States, and 10 years ago entry costs were proportionately a lot lower than exit costs.

The world has changed, just as it has ch[illegible]ed in Eastern Europe and the Soviet Union and Nicaragua. W[illegible] has changed is that entry costs, because of the pace of innovation, is changing all the time and it is those entry costs to get into high value added or more productivity, whatever the term you use, that is not recognized in anybody's equation any more. It isn't recognized in the macro-economic equation, and I think you have to look at that more thoroughly than you have. That particular problem has to be articulated, defined, identified and laid out there because otherwise no one, and I'm thinking of John Sununu, is going to understand exactly why the world is different, and he has got to understand.

Thank you.

Mr. GIBBONS. You're quite correct, Senator. I think this business of entry cost and the thresholds one has to cross for certain key new areas that are so fundamental and so broadly applicable to future manufacturing are so high that the risk sharing, if we're going to do it, the public needs to risk share along with benefit as a result of it.

Senator HEINZ. Mr. Chairman, thank you.

The CHAIRMAN. Well done. It was very important, and I think this helps lead logically to our next witnesses are private sector witnesses who are out on that high frontier of technology and major investment for breakthroughs.

Senator Bryan, anything else?

Senator BRYAN. I would yield. Let's hear the next panel.

The CHAIRMAN. Very good.

Let me thank our witnesses for their good work and their comments, and we'll have more questions for you from the record.

Let me invite our other witnesses to come forward, Mr. Ross and Mr. Kane.

I want to indicate for the record as well that Senator Dixon was here earlier. He has a great interest in these topics and has been a leader in the question of technology transfer and the whole question of the Defense Production Act, and his important role also is to be noted as we go here.

Senator HEINZ. Mr. Chairman, as our witnesses are coming forward I would particularly like to claim Ian Ross as a partial resident of Pennsylvania. I understand Bill Bradley may disagree because AT&T is in New Jersey, but they do all their good work insofar as I'm concerned in Pennsylvania, both in Reading and in Allentown where they invented the chip. Dr. Ross, it's a pleasure to have you before the committee, if I may say so.

The CHAIRMAN. Gentlemen, we welcome you. You've heard the earlier part of the discussion. You both have been very deeply involved over a long period of years in these questions, not just in the private sector, but the public policy dimensions.

We're going to make your full statements a part of the record, and I would like you to feel free to summarize and go right to the things that you think are the most important for us to understand and that you want us to consider within the committee.

Dr. Ross, let's start with you.

## STATEMENT OF IAN M. ROSS, PRESIDENT, AT&T BELL LABORATORIES

Mr. Ross. Thank you, Mr. Chairman. I do appreciate this opportunity to appear as president of Bell Laboratories and as chairman of the National Advisory Committee on Semiconductors, and also as a one-time resident of Pennsylvania where I lived for 2 years in the Lehigh Valley, and we do do some of our best work in that area.

I was asked to comment on the contrast between the OTA report which we just heard about and the National Advisory Committee on Semiconductors report which was issued in November of last year and I will try and do that.

First, let me comment on the National Advisory Committee on Semiconductors. It is a national committee. It contains eight industry members and five Government members. It was created by the Omnibus Trade Bill to advise the President and Congress and it's focusing on semiconductors. It was appointed by the President. The committee was brought together a year ago in January.

We were required by the trade bill to provide an annual report about the November timeframe, which we did, and that was an interim report. It has a lot of strong recommendations. We will be the first to admit that it needs further work, but I think it was important that we came to the Nation with our observations and concerns.

Now although the OTA report is aimed at manufacturing in toto in the United States, while the National Advisory Committee on Semiconductors is aimed at the semiconductor industry, there is substantial and remarkable agreement among the two reports. I don't find anyplace where we are differing substantially, although we're looking at a subset.

So let me concentrate on the semiconductor industry as described in our report, an industry that we consider to be a strategic industry and the title of our report refers to it as a strategic industry at risk.

Now as you probably know, the semiconductor industry underlies most of the electronics industry which worldwide is $750 billion of revenue and in the United States it's 2.6 million of those high-skilled jobs that you talked about. It touches almost everything we do in defense, in medicine, navigation, weather, entertainment. It is a key to our national security. There's no question that superior electronics can deal with superior numbers and I submit to you as peace is breaking out it is probably more important that we retain the technical superiority because we can always rebuild in a hurry the numerical superiority for parity.

It is also a technical driver to much of industry and academia.

The CHAIRMAN. Can I just stop you for a minute. Was the point that you just made in passing that with peace breaking out it may in fact be more important—was that the inference of your comment?

Mr. Ross. I think it is at least as important, if not more important, to retrain that technical capability that can offset numbers.

The CHAIRMAN. And part of your theory was that if you've got to do something in a hurry like mobilize or if the world changes in an adverse way, then you've got the internal capacity to make a big move in a hurry. Is that what you're saying?

Mr. Ross. And this entry problem that Senator Heinz was referring to is much less there than there is if you've lost the technology.

Now in our report we looked at the semiconductor industry and we saw distressing evidence of decline. Everything we looked at in terms of market share suggested that we were losing market share in the United States compared to Japan. And although you could claim that if we froze the market shares at where they are today we would have a healthy semiconductor industry, what we are seeing is continuing trends down and no reason to believe that those will turn around unless something different happens.

The most critical thing and most urgent thing we saw was in what is called the SM&E industry, the semiconductor materials and equipment industry. These are the many companies that supply the common equipment and the common materials that are used by all semiconductor industries throughout the world and in the United States that decline is extremely rapid. Very large percentages of what are being used today in the U.S. semiconductor industry are imported and our report shows numbers in the 1970's, 1980's and even approaching 90 percent.

Our belief is that unless something is done about that portion of the industry within the next 2 to 3 years, we could lose that capability mainly to Asia, partially to Europe, and we may find our-

selves forced to be one generation behind the technology because of that lack of supply.

Now we looked at the root causes and to summarize those we saw them in the business environment just as the OTA report does. The most critical there being the cost of capital. And we see this factor of two, however way you cut it, higher in this country compared to Asia, and that does cause people to make shorter-term decisions than if you have lower capital rates.

We also looked at the market for U.S. semiconductors and there we are particularly concerned about the loss of market to the electronics industry and to the consumer electronics industry. We have almost totally exited the consumer electronics industry in this Nation and that today used about $11 billion of semiconductors of which less than $1 billion is supplied by the U.S. semiconductor industry, even though the Nation consumes a much bigger proportion of consumer electronics. This is a very critical market loss, but it's more than that.

As has been referred to, at one time, the technical driver in electronics was really the defense program. About 10 years ago that shifted to the leading high technology industries like computers and telecommunications. It is now shifting again. And consumer electronics is beginning to drive the leading edge of electronics technology. When you look into a compact disc machine it has enormous processing power. When you look at camcorders for today's television, let alone for HDTV, that is driving the number of components that you need to put on a chip. So we see this as doubly important.

Finally, we looked at our technical problems and there we feel that U.S. industry has erred in being late to recognize the benefits of cooperation among industry and with Government in what we refer to as the precompetitive phases of an industry. There are a number of things that all industries use in common, all parts of the industry use in common. Yet because of our desire in industry to compete in everything, we've tended to multiply that kind of investment rather than be willing to compete, to cooperate in those precompetitive phases and then compete vigorously in the competitive phases.

Now we have some recommendations in our report on the environment. They track very much the OTA. We feel the cost of capital should be reduced by balancing budgets, increasing savings rates. We're concerned about education, about intellectual property, about trade laws, antitrust. These are all things that you've heard before and they were in the President's Commission on Industrial Competitiveness that I helped write 5 years ago.

As far as the loss of market, particularly the consumer electronics market, we made two recommendations. One is for a private capital corporation that would try and provide low-cost patient capital to enterprises willing to get back into the consumer electronics industry.

Our second recommendation is to have a national initiative to bring fiber optics to the customer premises and particularly to the home. We see that as providing an important infrastructure that can stimulate the U.S. electronics industry.

Then finally, on this question of the important semiconductor materials and equipment industry where we see a desperate need for help very short term, we cannot wait, we are recommending increasing the funding of SEMATECH which looks to us like a very good example of a cooperation among industry and Government. We are recommending as soon as possible additional $100 million funding for SEMATECH per year of which 50 percent would come from industry.

Well, in conclusion, we find ourselves very much in agreement with the OTA report. We see the problem in the semiconductor industry as serious and getting worse, and frankly what we are now doing is not working and we feel something different needs to be done.

Thank you very much.

[The complete prepared statement of Ian M. Ross follows:]

TESTIMONY OF IAN M. ROSS

President, AT&T Bell Laboratories

BEFORE THE COMMITTEE ON

BANKING, HOUSING AND

URBAN AFFAIRS

SENATE

February 28, 1990

Mr. Chairman and Members of the Committee:

Thank you for having me here today not only in my capacity as President of AT&T Bell Laboratories, but also as Chairman of the National Advisory Committee on Semiconductors (NACS), to comment on the recent report of the Office of Technology Assessment (OTA) entitled, "Making Things Better: Competing in Manufacturing."

I have been requested to give my views on the government's role in promoting U.S. manufacturing competitiveness, and how a loss of competitiveness could affect the standard of living of our citizens and our national security. It was suggested that I contrast the substance of the OTA's report with that of a report entitled, "A Strategic Industry At Risk," which was prepared by NACS and submitted to President Bush in November 1989.

The OTA's report provides a thorough analysis of the current state of the U.S. manufacturing industry and leads to the conclusion that the U.S. has already lost, or is rapidly losing, world leadership in many key manufacturing industries, such as, to name a few, semiconductors, consumer electronics, automobiles, and computers. While the OTA's report does not recommend specific actions to reverse this trend, it does provide an in-depth look at the pros and cons of available policy options that might be considered in responding as a nation to the challenge of rebuilding our manufacturing processes, perhaps the most significant deficiency U.S. firms have exhibited in recent years. The OTA's report reaffirms the general belief that America is still a world leader in innovation but it has a long way to go in getting competitively priced, high quality products embodying such technology to market.

The reasons set forth in the OTA's report for the decline of the U.S. manufacturing industries closely parallel those set forth in the NACS report for the decline in the U.S. semiconductor manufacturing industry.

Both reports, in essence, highlight as root causes of our predicament the lack of low cost capital, a workforce deficient in educational and vocational training, an unsympathetic legal climate both in the antitrust and intellectual property areas, and manufacturers' shortcomings, especially in their failure to use quality initiatives, and in lack of cooperation. Indeed, the agreement between the findings of the OTA report and the NACS report for the semiconductor industry is striking. The broader based OTA report finds many, and sometimes most, of these same ills in other segments of U.S. industry.

Since the OTA findings show that the problems of the semiconductor industry are illustrative of the problems of many industries, in the limited amount of time I have here today I would like to use the semiconductor industry as a vehicle to convey to you the problems of U.S. industry found in both reports.

National Role of Semiconductors

The semiconductor industry, as the foundation for all electronics-based industries, is of major strategic importance to the United States, both economically and militarily. Consumer products, computers, telecommunications, military equipment, and other industries with products incorporating electronics are largely dependent upon the semiconductor industry. The semiconductor was invented and developed by American industry, and was dominated by U.S. firms for three decades. But, during the 1980's,

Japanese companies, with coordination and encouragement from their government, have aggressively expanded their semiconductor industry into a dominant position in the world marketplace for semiconductors. As a result, world leadership in several critical areas of semiconductor manufacturing technology has tended to shift to Japan. Firms that deal in semiconductor materials, and semiconductor manufacturing equipment (SM&E) and related instrumentation are being hurt by a shrinking supportive market in the U.S. and have lost a significant share of their market. Furthermore, many of the manufacturing tools essential for achieving increased productivity, lower costs, and higher quality in industrial production are products of the semiconductor industry.

2.6 million American jobs, more than double the jobs in America's steel and auto industries combined, depend upon the world market for electronics products. The $750 billion world market for such products is leveraged by the $50 billion world chip industry. Increased demand for electronic products, resulting from improvements in their cost and performance, prompts the producers of such products to support development of more advanced chip technology to further improve performance and costs and, thereby, further increase demand for their products. Thus, successful makers and sellers of electronics products like computers, microwave ovens, televisions, anti-lock brakes, and phone systems demand innovation from the semiconductor industry.

Manufacturing Decline

Over the past decade, Japan has taken over market leadership in the world from the U.S. merchant semiconductor industry. In 1980, the United States enjoyed more than double the worldwide market share of its nearest competitor, Japan. We

dominated that market. But, by 1986, we were passed by Japan; and, by the end of last year, more than 50 percent of the world market belonged to Japan. Our share had dropped below 40 percent. We experienced market share losses not only in the well publicized leading-edge VLSI chips, but also in very simple high volume chips containing only a few transistors. The relatively equal 40 percent market positions of Japan and the U.S. for discrete devices in 1980 has now deteriorated to a less than 30 percent share for the U.S. and a more than 50 percent share for Japan. Discrete devices are of major importance both to military hardware and to many consumer products.

Maintaining a leading-edge chip technology becomes more expensive with each successive technological generation. Among all types of American industry, chip producers are at the forefront of annual investment (as a percentage of total revenues) in research and development, and in new plants and facilities. The cost of one state-of-the-art facility for semiconductor memory chips has risen eight-fold since 1980, from $25 million to $200 million. Further increases are expected over the next several product generations, raising the cost for state-of-the-art manufacturing facilities to between $500 million and $750 million. The American semiconductor industry, during this last year alone, spent around $3 billion on R&D, and another $3.5 billion in capital investment. The resources of even very large firms are strained by such expenditures.

OTA and NACS found that even with such high investment rates compared with other American industries, our semiconductor industry is being outspent by our major Japanese competitors. The top five Japanese firms spend nearly twice as much on R&D as is spent by the top five American firms. Increased revenues from an increased world market share are reinvested by the Japanese firms and account for much of this

difference in spending. The OTA report observes (page 1-12):

> **"Company size and structure may account for some of the myopia of the semiconductor industry, in particular. The leading Japanese semiconductor producers are large, integrated, stable companies making a variety of products, from semiconductors to computers and consumer goods. The U.S. industry has a few large, integrated producers making chips mostly for their own use, but the merchant firms that sell semiconductors to systems makers are mostly smaller, entrepreneurial companies. Such companies have been highly innovative, but also highly unstable. Personnel turnover (especially defections to start new firms) is high, as are rates of entry and exit. Their relatively small size, instability, and irregular cash flow make it especially hard for them to raise the large amounts of capital required for semiconductor production. These factors exaggerate the short-term focus that is endemic in U.S. financial markets."**

Japanese semiconductor revenues multiplied by a factor of six from 1981 to 1988, while revenues of U.S. producers merely tripled. This huge growth in the sales revenues of the top Japanese firms is funding an impressive level of investment in R&D and capital equipment with which to support further growth in Japan's share of the world semiconductor market.

Loss of market position by U.S. firms is equally apparent for key products, such as integrated circuit memory chips. Japan had a zero share of the market when the first integrated circuit memory was sold in 1970. Since then, Japan's share of the world market for memory chips has grown to 80 percent in 1988. This is particularly significant since technical improvements over a broad range of process and manufacturing technologies applicable to other semiconductor products are driven by leading-edge memory technology. The loss in world market position by U.S. chip producers has seriously affected America's position in many important areas of semiconductor technology, especially in relation to Japan. We are holding our position

in only a few areas. Technological knowledge is cumulative. This point is brought out in some detail in the OTA case study on HDTV beginning on page 2-92 of its report.

Semiconductor Materials and Equipment (SM&E) Decline

Driven mostly by memory device technology, the international semiconductor industry pursues ever finer design rules. Device features have reached the submicron level, i.e., less than 1/50 the diameter of a human hair. Eighty-five percent of all leading-edge manufacturing capacity for submicron wafers is now in the Far East. This has been very detrimental to parts of the SM&E industry in the U.S. because large foreign chip producers prefer to work with their local SM&E suppliers, which they can control. Such close working relationships result in synergistic equipment advances by the foreign SM&E firms as they work at the leading-edge of technology with local chip producers. The previously commanding market share of America's SM&E firms that produce lithography equipment, test equipment, and materials, has deteriorated significantly. Although our SM&E firms dominated in the early 1980's as worldwide suppliers, the market is now dominated by Japanese firms. This point is noted in the OTA report (page 1-19).

> **"The decline of the American textile machinery industry has not, it seems, crippled American textile makers. Nearly all report satisfactory service from their foreign suppliers. The same is not true of semiconductor production equipment. As recently as 10 years ago, American firms held more than three-fourths of that world market. By 1988, the U.S. share was down to 47 percent and still dropping (table 1-2, figures 1-16, 1-17, and 1-18). This year, Perkin-Elmer, one of the major remaining U.S. manufacturers of lithography equipment, decided to drop out of that market, which had become a money loser for the company."**

Consequences to the Nation

I believe that the evident decline of the semiconductor and SM&E industries in the United States is unacceptable. It is essential that we have a microelectronics industry that is locally based, locally controlled, and incorporates a full complement of leading-edge activities ranging from research and development through production, with costs, quality, and performance second to none. Neither imports nor foreign direct investment can, for the foreseeable future, allow America to receive the same level of benefits - military, technological, or economic - that an American microelectronics industry can produce.

The consequences are perhaps best seen from the perspective of national security. The qualitative edge in advanced weaponry and other military hardware underlying our strategic position should not depend on foreign trade flows that can be disrupted, and should not depend on foreign-owned manufacturing, even if it is physically based in the U.S.

Without a healthy semiconductor industry in the U.S., foreign competitors would have the leverage to control the flow of economic gains from microelectronics to the rest of our economy. Our foreign competitors, particularly the Japanese, have demonstrated their ability to cooperate so as to exercise market power and control both the access to and the price of critical technology. Our supercomputer companies have been unable to purchase the fastest foreign chips. The OTA report at page 1-20 notes:

> **"For example, the highest performance memory and bipolar logic components for supercomputers come only from Japan; the management of Cray, America's only remaining supercomputer maker, has at times been told that the latest and best of these components are "not yet available for export" from Japan. They are, however, available to Japanese supercomputer makers, and the Japanese supercomputers themselves are ready for export. Closer relations with U.S. suppliers is not just an advantage but a necessity for maintaining market share, in a world where a firm's major suppliers are its fiercest competitors."**

The majority of American chip producers cannot get access to the most advanced foreign semiconductor manufacturing equipment and materials on a timely basis. Remember the shortage of Dynamic Random Access Memory (DRAM) chips? American industry has lost control in many of these areas and the future is cloudy. For example, with respect to lithography equipment used in the manufacture of semiconductors, the OTA reports (page 1-19):

> **"The next generation of lithography equipment is expected to use X-rays, and the Japanese are well ahead of American producers in developing X-ray lithography equipment. If commercial use of X-ray lithography equipment begins, as expected, in the 1990s, it is likely that the first use will be in Japan, a development which will add to the already substantial number of microelectronics technologies Japanese producers dominate."**

Critical Factors

Foreign and domestic business policies and practices competitively detrimental to American industry; lack of full government support in the American business environment; shifts in markets for electronics products causing reductions in the markets for U.S. semiconductors; all of these are factors contributing to the loss in world position suffered by the U.S. semiconductor industry.

OTA and NACS agree that the comparatively high cost of capital in the U.S. seriously disadvantages American semiconductor firms and other industries as well in competing effectively with Japanese manufacturers. The OTA report illustrates that capital costs in Japan are significantly lower than are capital costs in the United States. The report further states (page 3-7):

> **"Moreover, Japan's financial system spread the risks of long-term investments in industrial development widely among banks, savers, consumers, and corporations. This was done through controlled interest rates; tax policies that limited consumer spending, encouraged saving and transferred household savings to businesses on very favorable terms; and a variety of tax incentives that reduced the cost of investment. In America, much more of the risk of long-term investment is borne by the corporation itself."**

This is very significant to the availability of capital investment for expanding domestic industrial capacity, as the Japanese semiconductor industry did heavily early in the 1980's. It is important that the availability, cost, and patience of capital investment in U.S. industry be improved. Lower risk in investment decisions, longer time considerations for operations, and increased immunity from business cycle changes are advantages which result within a low cost and patient capital investment environment.

Electronics systems provide the major market for semiconductor chips. Production of these systems is migrating to the Far East, carrying the chip market along with it. In fact, by 1984, Japan had supplanted the U.S. as the world's largest semiconductor market.

Even more significant is the shift from America to Asia of the major part of consumer electronics production. Consumer electronics products, like televisions, radios, and VCRs, are one of the fastest-growing segments of the world market for

semiconductors. As such, consumer electronics is a major contributor to research and development in semiconductor technology. Loss of a U.S. controlled consumer electronics industry has contributed to the decreasing ability of American semiconductor manufacturers to compete successfully with their foreign counterparts. Consumer electronics has become an effective driver of advanced semiconductor technologies, manufacturing techniques, and product costs.

OTA and NACS agree that another factor which has hurt America's manufacturing industries is their failure, until recently, to pool their research and development resources into cooperative precompetitive research efforts. The problem was discussed in the OTA report (page 1-16):

> **". . . American firms tend to be isolated from customers, suppliers, and competitors compared with Japanese and many European firms. Japanese firms, in particular, are knitted into a network of mutual obligation and cooperation. This is not to say they don't compete; competition is fierce, but is often greater in product quality and features than in price. The bonds of cooperation and obligation, together with relatively limited price competition in the Japanese market, provide Japanese firms with two advantages: access to a wider array of information and support than they would have alone, and enough stability to encourage investment in equipment, knowledge, and people."**

America's semiconductor industry needs a long-term perspective if it is to stay at the leading-edge of technology. High quality technology through steady incremental improvements is needed, along with an understanding that technical knowledge is cumulative over many product generations. Years before any resulting products are marketed, heavy precompetitive investments must be made in people, technology, and facilities. Major generations of semiconductor processes are started five or more years before marketable product generations result. Major product generations usually are

introduced about every three years. Thus, a semiconductor firm must bear concurrently the costs of at least two precompetitive efforts. This strains the financial resources of even the largest firms in the industry. Having recognized this problem for some time, Japanese firms regularly cooperate in precompetitive research, with substantial government involvement and assistance. The only comparable American effort is SEMATECH, a consortium of U.S. firms dedicated to improving semiconductor manufacturing technology.

Our foreign competitors also enjoy more supportive industrial policies and practices than do U.S. firms. Closed domestic markets and government subsidies contribute to a more supportive business environment in some foreign states. The rights U.S. firms have in their intellectual property often are difficult to enforce overseas, thus disadvantaging our companies in competing with foreign firms. Similarly, foreign chip producers often engage, with government sponsorship, in cooperative and coordinated behavior that would not be pursued in the U.S. out of fear of antitrust litigation. Such behavior includes cooperative research and development, concerted pricing arrangements and captive customer and distribution arrangements through, e.g., vertical integration and cross-ownership. A favorable business environment with the full support of government is needed in the U.S.

OTA and NACS emphasize that the semiconductor high technology industry must have well-trained workers, engineers and managers. Competitive performance of such industries is highly dependent upon the quality of the work forces. Measures are needed across the entire spectrum of education in the U.S., from pre-schoolers to graduate students to the active workforce, so as to produce the well-educated workers we

need. They must be able to adapt to new technologies and be sufficiently flexible to respond quickly to increasingly sophisticated and demanding work environments, such as those of the semiconductor industry. The degree of illiteracy among American adults is a national disgrace and severely handicaps our work force.

The OTA report concurs in highlighting this educational deficiency. At page 1-15 it also points out the deficiency in vocational education:

> **"Not only is our general public education inadequate, our vocational education system falls far short of the standards set by other countries. It certainly does not match the apprenticeship training taken by more than half the young people of West Germany. This system gets much of the credit for the broad diffusion of technical competence throughout German manufacturing."**

Our universities have emphasized theoretical disciplines compared to practical manufacturing training. Additional emphasis must be placed on training in manufacturing enginering, and courses are needed to support advanced applications of total quality control. In addition, government action should be taken to enlarge the U.S. population of highly qualified scientists and engineers with advanced degrees.

NACS Recommendations: Toward a National Strategy

Timely industry action, supported by government, is required to arrest the deteriorating global position of U.S. semiconductor industry. Industry and government must cooperate, with each providing its special strengths and acting in its appropriate role. The National Advisory Committee on Semiconductors has developed the following recommendations that serve as initial steps towards the development of a comprehensive national semiconductor strategy.

1. Re-establish a fully competitive and supportive business environment in the United States to enable the U.S. semiconductor industry to operate on an equal footing with its major international competitors by:

   a. Promoting capital formation;

   b. Improving the education system;

   c. Reforming trade law;

   d. Enhancing protection for intellectual property; and

   e. Improving the antitrust climate.

2. Expand the U.S. industry's global semiconductor market share by rebuilding a strong U.S. position in the growing high-volume, high-technology electronic systems market by:

   a. Building a supportive business environment. There are several inseparable actions that must be implemented as a unit to accomplish this:

      - Establishing a for-profit Consumer Electronics Capital Corporation (CECC) to resurrect the U.S. consumer electronics industry infrastructure by providing a multi-billion dollar pool of very patient, low-cost capital;

      - Urging the President to direct the appropriate agency to determine those factors which reduce the likelihood of a successful U.S. consumer electronics industry. Redress shall then be immediately sought through cooperative agreements

(with non-U.S. corporations), consumer electronics technology licensing, local technology content minimums, and local R&D and design (or any combination of the preceding); and,

- Having the Federal Government encourage and purposefully support the re-entry for the U.S. consumer electronics industry and its potential to compete vigorously. Accordingly, the Office of the U.S. Trade Representative shall ensure that access to the U.S. consumer electronics market shall be contingent upon reciprocal opportunity for U.S. companies to access foreign markets.

b. Providing expanded market opportunities by encouraging private industry to accelerate the development of a nationwide broadband network providing fiber-optic cable to the home, by modifying regulatory policy where necessary and broadly experimenting with prototype trials.

3. Enable the U.S. semiconductor industry to retain an enduring world-class, competitive technology position with a healthy semiconductor manufacturing equipment industry by:

a. Accelerating research and development in the U.S. semiconductor materials and equipment industry by expanding the mission of SEMATECH, the semiconductor manufacturing technology consortium, in this area. SEMATECH's funding should be increased immediately by $100 million, half of which should be provided by the industry. Additional funding of

$800 million will be required over the next 3 years for these programs fully to address the needs of this industry segment.

b. Sustaining the current Departments of Defense (DOD) and Energy (DOE) funding of $200 million per year that was previously allocated to very-high-speed integrated circuits and direct it toward maintaining long-term industrial R&D efforts related to silicon technology and manufacturing tools.

c. Ensuring that the DOE transfer synchrotron ring x-ray technology and systems for microlithography to U.S. industry and aggressively pursue, with DOD's Defense Advanced Research Projects Agency, and the Department of Commerce programs in mask making, mask repair, aligners, metrology, and small x-ray sources.

Conclusion

This has not been an encouraging story. I've personally witnessed the transformation of the world semiconductor industry from one in which America was the clear leader to one in which we are number two in market share. The gap continues to widen, giving use to serious implications involving urgent issues in troubled times. These issues must be addressed with a national strategy involving both the public and private sectors. Concentrated action of an extended period by both industry and government will be needed to revitalize our domestic semiconductor industry and to reverse the trends I have described today.

The CHAIRMAN. Thank you. I just want to react briefly at this point and invite my colleague to do the same. I think you're one of the most competent people in the country to assess these questions. You're the president of the AT&T Bell Laboratories. It's an esteemed organization by its record and achievements. You've been at this for many years. If we were to find ten people in the country or five that could really address these questions in a very focused competent way at the highest level of professionalism, you would certainly be one of those people.

You helped produce that national report on competitiveness 5 years ago. I thought it was a sensational piece of work. I thought it was something that the country needed to pay attention to and by and large I think it's been gathering a lot of dust since that time. I don't see the major push by the country as a whole in any strategic way to really take hold of the findings there and the recommendations there and do something about it so that debate goes on. It rolls forward. We're back here today. It's 5 years later and we're making many of the same points.

I think there is an emerging consensus in the country among thoughtful people as to what the elements of the strategy are, and they are really quite simple in terms of getting the cost of capital down, driving the rate of technology faster, increasing our capital investment and our human investment with education.

The one thing that the passage of time has done is to refine the insight into the argument enough so that we have a pretty good sense now as to what it is we need to do.

Our problem is we don't seem to be able to wake anybody up that runs the Federal Government. And I don't say that disrespectfully to any particular person, but I recall when you were ready to present the national report on competitiveness 5 years ago, rather than doing it in the east wing of the White House where it probably ought to be done or out on the back lawn of the White House where other reports are made public, it was done down in the auditorium of the Commerce Department in town which is not even an easy place to find. I mean you really have to want to get to the Commerce Department auditorium to find it.

So we've had a deliberate I think underattention paid to these issues.

Now how can it be that a person of your stature and your responsibility in the private sector can't get this message across? Why can't we get the executive branch of Government, which really has to help lead the charge here, fully engaged in this issue? What happens when you talk to the President—I mean this President, the last President—can you talk to them? Do they listen? What happens?

How do we go about getting the switch turned on so that somebody up top says it's time to really move this country ahead at a much faster rate? Where is the breakdown?

Mr. Ross. Well, I appreciate your comments. The report on the Presidential commission or the reception of it was really rather disappointing and frustrating, but at that time the main response we got was there isn't a problem. In fact, there were even people who were saying we can let our industry go overseas, we can become a

service economy. That kind of nonsense was being talked about seriously.

I'm encouraged that in 5 years we've gone from that to most people saying, yes, we have a problem and, yes, we must keep our industry within the United States. I find that very encouraging, although it took quite a while.

I think what we're facing now and it's been alluded to earlier, that we've got to admit that what we're doing now isn't working, that we are not necessarily dealing with other people who are playing the game the same way we do, and all of us have got to be willing to face up to some changes in the way we do business, the way we run our Government, the way we pay our taxes. Some of these things are bitter pills.

I think the only solution here is for all of us to stake it the way we see it and not be shy in stating problems and coming up with solutions even though they may be controversial—proposed solutions.

The CHAIRMAN. Well, I've made a comment and given you a chance to respond and I should do the same with my colleagues and then before we get into elaborate questioning I think we ought to let Mr. Kane make his comments.

Senator Heinz, would you like to comment?

Senator HEINZ. I will reserve my time.

The CHAIRMAN. Senator Bryan.

Senator BRYAN. I'll do the same, Mr. Chairman.

The CHAIRMAN. Mr. Kane, let us hear from you now.

## STATEMENT OF SANFORD L. KANE, U.S. MEMORIES

Mr. KANE. Thank you, Mr. Chairman.

I'd just like to start by making one quick comment about the OTA report itself. Having had the opportunity to read it thoroughly, I must say that it is extremely well done. It is thorough. It is to the point. And amazingly enough for this kind of document, it's also very readable. I am hoping that with that last attribute that there will be a lot of people who will read it because I am in almost complete agreement with what I read in that document and I hope that it will get a lot of people's attention.

I appreciate the opportunity to appear before the committee today. I feel very strongly that the economic leadership in this country and in the world economy, especially in the area of high technology in which our economic future depends, is challenged as it never has been before. And it is very much rooted in the fact that we are becoming less competitive in the world environment than we have been in the past.

It is to me a good sign not just that this report is being published but that the committee thinks enough of it to have a hearing on its publication today. It's an indication to me that we are getting an increase in our attention to this problem and I'm encouraged by that.

I don't have, beyond the kinds of things that are in the report, any simple formula for success of what we must do to restore America's competitiveness. I think it would be a good idea, however, to spend a few moments based on recent and, unfortunately, un-

successful efforts in trying to put U.S. Memories together, a venture that was designed to do a lot of the kinds of things that are talked about in this report to make dynamic random access memory in the United States and regain some of the leadership that we've lost in that area for the computer and electronics industry in the United States.

I think that spending a little time on the story of that experience, if you will, will hopefully add something useful to the debate. I think it's important, however, to spend a couple of minutes first on what I think are some of the changes that have been taking place in the nature and intensity of the world competition. If it weren't for those changes, then some of the old tried and true techniques that have done so well probably still would be. So I think it's important to focus on those.

I believe clearly that for America to meet the challenges that we are being presented with will require some fundamental reorientation in the structure of the U.S. economy.

The first of those changes that I want to focus on is the development of what we call a truly global marketplace. There are virtually no industrial products that are made in the United States today that don't face foreign competition. Similarly, a large and increasing share of potential sales for products made by American companies is overseas. There is no sector where this is more true than in high technology products, where there is a high value-to-volume ratio that has virtually eliminated the question of transportation costs being a major factor from a competitive standpoint. So that's no longer an issue.

A second change that's sweeping the industry in general and clearly high technology in particular is the evershortening product cycles that we are seeing in new generations of products. That spiral of technology advance means that each new generation of products follows more closely on the heels of its predecessors and we are finding some of our scientists or engineers are working on the next generation design even before the latest generation is out in the marketplace.

In this kind of an environment, if you make any kind of major misstep, it can be fatal. Once you get out of a business because you've made one of those kind of missteps, reentering the business is very difficult, very expensive, and very risky.

Also, closely related to that shortening product cycle is another attribute of the new competitive age which was mentioned in the discussions by Mr. Gibbons and his staff, and that is the immense and rising R&D costs that we are seeing.

The U.S. semiconductor industry research and development bill—over recent years and most specifically in 1988—was 11 percent of their total sales. That is higher than in most industries in the United States and it indicates that as you go to higher and higher levels of technology, the cost of staying in that business and betting on your future increases dramatically.

Obviously, it also means that if you make errors in any single company, it can have detrimental effects on that company.

Then you come to manufacturing. Clearly, manufacturing is where the greatest relative decline has occurred in U.S. competitiveness. At least for the last decade the Japanese in particular

have greatly outpaced U.S. manufacturers in the application of advanced technology and in productivity increases in the manufacturing process. They have focused on it. It has been a clear area of attention that they have done and we have not.

Once a product is developed, the costs of production—another one of these areas that has changed—are often even more staggering to worry about. The construction of a fabrication line to produce 4 megabit memory chips in the area of the kinds of things we wanted to do with U.S. Memories can take as long as 1½ to 2 years to produce and cost in excess of $400 million before you ever get the product out the door.

Obviously, with these kinds of costs, as well as the R&D costs, you need to have very high volumes for a company in order to be able to have a chance of making a profit.

The high technology sector in the United States has always benefited from the entrepreneurial efforts of small and highly innovative companies. Some of the great advances over the last 20 years have come out of the garages of some forward-thinking young scientists and engineers. Many of the greatest success stories in the past few years have been done by relatively small niche companies that identified a very specific need and went and filled it. Niche companies, however, can't survive without an infrastructure in which they can assume specific roles and from which they can draw talent and expertise and components and equipment and a market. It's clearly well known that most of the leading entrepreneurial companies, the ones we all know about, were started by people who learned their trade in the laboratories and on the production lines of larger companies. The niche companies don't exist in a vacuum. They operate in an environment that provides them the support that they need.

As technologies become more sophisticated, the basic infrastructure has become more and more expensive to maintain. In many cases these costs are so high that they can't be borne by single companies. Even companies like IBM, at which I spent 27 years before I left to do U.S. Memories, which many people perceive has vast resources, can't afford to go it alone. If the basic infrastructure is to be maintained, both horizontal and vertical cooperation of various types between companies in specific areas is absolutely critical.

In addition, the Government needs to reconsider its traditional antagonism toward cooperative efforts among high technology firms where they offer significant benefits in tackling tasks that single firms lack the resources to undertake or which pose inordinate risks for a single firm. The alternative is to have markets that would be captured by large, integrated foreign competitors who have the resources, the Government support, and unflinching perseverance to dominate and stay with it. This is a result that I'm sure most of us would like to avoid.

U.S. Memories as a joint venture was conceived as a response to the serious competitive difficulties that are being encountered today by both semiconductor and computer systems manufacturers in the United States. The systems manufacturers are being threatened by their dependency on vertically integrated Japanese competitors for the memory devices on which their machines rely. If

there is another—I shouldn't say if—when there is another serious and protracted shortage of memory, because the "if" is not part of the equation, the only question is really when it will be—it clearly will mean, as it has in the past, that the systems manufacturers will be literally dependent on their own competition for these necessary supplies of memory and in many cases will find that they will have to stop their assembly lines because they won't have enough product to be able to ship their product in the marketplace.

When memory is available they will find that they are paying extremely high prices for them relative to what the normal market would be.

United States producers have encountered delays also in obtaining new state-of-the-art devices because what we are finding is that the vertically integrated Japanese competitors have favored their own computer affiliates whenever there are tight supplies.

At the same time, the semiconductor manufacturers have found themselves threatened by the virtual elimination of the U.S. memory production capability. We have always found in the semiconductor arena that memory production, DRAM's in particular, are what we call major technology drivers. In other words, the lessons that we learned by developing and manufacturing DRAM's are carried over into other areas of semiconductors. The massive DRAM activities that generate a broad economic base that can then support future technical and personnel requirements of other semiconductor areas as well.

Although these kinds of problems were first encountered by smaller companies, even IBM came to realize that it needed to help preserve that U.S. infrastructure. Ian described in some detail the kinds of problems that we are seeing in the equipment and materials industry in the United States and it's very much a part of that infrastructure that I mentioned.

Although IBM is clearly the world's leading memory device manufacturer, it's also a very high purchaser of DRAM's in the marketplace and they realize that if they didn't find ways to change the environment in the United States they would be in the position where they would have to become dependent on some of their chief competitors like NEC or Fujitsu or Hitachi for DRAM's. Recognizing that kind of situation, IBM undertook a fundamental reorganization of its corporate strategy and began to seek to share its technology in various areas and its resources with other U.S. companies and sought to encourage cooperative activities.

U.S. Memories was intended to address the kinds of difficulties I described. It was to harness existing U.S. technologies—in our case, specifically, IBM state-of-the-art 4 megabit DRAM's—for the broader use of U.S. industry. It was devised to offer an assured, stable supply of state-of-the-art memory devices to computer manufacturers that invested in the venture.

Finally, it was intended to increase competition in the memory market by introducing a new player.

As you all know, unfortunately, that concept failed. Many reasons have been advanced for the failure to attract the necessary support of investors. Among the explanations that have been put out are the cyclical DRAM surplus and concomitant falling prices that we've seen, the entry of Korea in to the field of DRAM pro-

ducers, the difficult financial circumstances of many companies in the computer industry, antitrust concerns, and the inability of the project to move as quickly as many would have hoped it would have done.

While these may be relevant, it's clear that none of those reasons were primarily responsible for the failure to launch U.S. Memories. It was intended as a long-term project and the present market downturn likely would have been long past by the time our fabrication lines were actually revved up. Korean entry in the market is significant but they are not much different than the large Japanese producers that are already dominating the market. And in spite of the tight financial situation in some of these companies, the resources for the project that we had in mind were available if a broad range of companies had invested. Antitrust issues were clearly an issue and were difficult to deal with but clearly not insurmountable and we proved that to be the case.

And the slow progress of getting this thing off the ground, much to our chagrin, was clearly not the cause but a symptom of the problems relative to the failure.

I would argue that the primary explanation for the failure of U.S. Memories was the inability on the part of many in the U.S. industry to confront long-term strategic problems and a deep-seated reluctance throughout the industry to undertake cooperative activities with traditional rivals. Most of the companies that we approached—in fact, all of the companies we approached made it very clear that the principle we were trying to put together in U.S. Memories was a sound concept, a good idea and well structured; yet they ultimately weren't willing to invest. This was the result of a short-term go-it-alone attitude, if you will, and an adversarial mindset toward suppliers that the companies simply could not transcend. Exactly the opposite of the kind of relationships that exist in Japan.

At root, the American businessman apparently still believes in the spirit of rugged individualism. This attitude has brought America a long way, but like every viewpoint that eventually becomes dogma, it can be taken too far. Competition is a good and healthy and necessary thing for high technology companies, as it is for society at large, but there are areas and instances where cooperation is necessary if individual efforts are to bear fruit and when we find those areas where cooperation is necessary it doesn't mean that we stop being competitive with one another.

The high technology sector in this country must be willing to cooperate to ensure the viability of key enabling technologies the existance of which are essential to the continued success of individual entrepreneurial efforts. Unfortunately, the failure of U.S. Memories shows that the sector is not yet fully prepared to recognize and act together to confront some of these long-term strategic problems.

Launching a major cooperative venture in manufacturing with several industry participants was clearly a formidable challenge. SEMATECH paved the way for the kind of cooperation that was necessary in the semiconductor industry by successfully undertaking the R&D in generic manufacturing technology. U.S. Memories represented a long step beyond SEMATECH, a far-reaching effort

into joint production itself and I would say we came very close to getting it off the ground.

If ventures like U.S. Memories are to realize their potential, it is clear that the U.S. Government will need to help to create an environment in which they can succeed. A variety of measures, most of which are mentioned in the OTA report, will be helpful if we can do some of these things quickly.

We need to adopt a permanent R&D tax credit. We need to adjust the U.S. antitrust laws to facilitate joint production ventures. We need to reduce significantly the U.S. budget deficit. And we need to find all kinds of ways of lowering the cost of capital.

Equally important as these concrete measures, the U.S. Government can lead the way toward placing greater emphasis on technology development and improved manufacturing as crucial means for enhancing our Nation's standard of living and national security. In such an environment, U.S. industry will clearly be able to respond strategically and to restructure and to meet foreign competition and regain their international preeminence.

Thank you.

[The complete prepared statement of Sanford L. Kane follows:]

STATEMENT OF

MR. SANFORD L. KANE

BEFORE

THE SENATE BANKING COMMITTEE

February 28, 1990

Mr. Chairman, I am appearing before this Committee today to address an issue of the greatest concern to the United States. The economic leadership of this country in the world economy, and especially in the area of high technology on which our economic future depends, is being challenged as never before. Our competitors in the Far East have replaced us as the world's leading producers in a number of product areas essential to success in the never-ending high technology race. In numerous other sectors, the competition is closing fast. We are reaching a critical juncture, and the choices we make now will determine how our children and our grandchildren live.

This Committee is, I am sure, well aware of the situation I am describing. It has been the topic of numerous hearings, debates, studies and discussions, both in government and the private sector. Presenting the problem is easy; prescribing a cure is another matter altogether. I have no simple formula for restoring America's declining competitiveness. I can, however, offer a few thoughts based on my recent, unsuccessful efforts to form U.S. Memories, a venture that was to bring American semiconductor producers and consumers together to produce memory devices. Perhaps the story of my experience will add something useful to the policy debate now raging.

**New Challenges in**
**High Technology Manufacturing**

There have been sweeping changes in the nature and intensity of world economic competition, especially in the high technology sector. I believe that for America to meet the challenge presented by these changes will require a fundamental reorientation in the structure of the U.S. economy.

Global markets. The first of these changes is the development of a truly global market. There are virtually no industrial products made in the United States today that do not face foreign competition. Similarly, a large and increasing share of potential sales for products made by American companies is overseas. In no sector is this more true than high technology products, where a high value to volume ratio has virtually eliminated transportation costs as a factor in the competitive equation.

Short product cycles. A second change sweeping industry in general, and high technology in particular, is ever-shortening product cycles. The dizzying spiral of technological advance means that each new generation of product follows more closely on the heels of its predecessor. Engineers often find themselves designing a new generation of product even before the previous generation becomes generally available. In this environment, a single misstep can be fatal. Once out of the business, reentry is extremely difficult.

High research and development costs. Closely related to shortening product cycles is another attribute of the new competitive age: immense and rising research and development costs. The U.S. semiconductor industry research and development bill in 1988 equalled 11% of total worldwide sales. The cost of developing a new generation is often so high that a single failure can mean the end of a company.

Importance of Manufacturing. Manufacturing is where the greatest relative decline has occurred for U.S. competitiveness. At least for the last decade, the Japanese in particular have greatly outpaced U.S. manufacturers in the application of advanced technology and in productivity increases in the manufacturing process.

Increasing economies of scale. Once a product is developed, the costs of production often are even more staggering. Construction of a fabrication line to produce 4 megabit memory chips (Dynamic Random Access Memories or DRAMS) can take 18 months to two years, and costs upwards of $400 million. Obviously, these enormous costs, as well as the research and development costs, must be spread over a large production volume if the company hopes to make a profit.

**The Need for Cooperation**

The U.S. high technology sector has always benefited from the entrepreneurial efforts of small, highly innovative companies. Some of the great advances of the past twenty years came out of the garages of forward-thinking young scientists and engineers. Many of the greatest success stories of the past few years have been by relatively small niche companies that identified a specific need and filled it.

Niche companies, however, cannot survive without an infrastructure in which they assume specific roles and from which they draw talent, expertise, components, equipment and a market. It is well known that most of the leading entrepreneurial companies were started by men who learned their trade in the laboratories and on the production lines of larger companies. These niche companies do not exist in a vacuum; they must operate in an environment that provides them the support they need.

As technologies become more sophisticated, the basic infrastructure has become more and more expensive to maintain. In many cases, these costs are so high that they cannot be borne by single companies. Even companies like IBM, which many perceive to have vast resources, cannot afford to go it alone. If the basic infrastructure is to be maintained, both horizontal and vertical cooperation between companies on specific ventures is necessary.

Government must reconsider its traditional antagonism toward cooperative efforts among high technology firms where they offer significant benefits in tackling tasks that single firms lack the resources to undertake or which pose inordinate risks for a single firm. The alternative is to have markets captured by large integrated foreign competitors who have the resources, government support and unflinching perseverance to dominate. This is a result I am sure most Americans would prefer to avoid.

**The Reason for U.S. Memories**

The U.S. Memories joint venture was conceived as a response to serious competitive difficulties being encountered by semiconductor and computer systems manufacturers.

Systems manufacturers were being threatened by their dependency on vertically-integrated Japanese competitors for the memory devices on which their machines rely. A serious and protracted shortage of DRAMs, not an unusual situation in this highly cyclical market, meant that systems manufacturers in some cases literally had to halt their assembly lines. When DRAMs were available, they were extremely expensive. U.S. producers encountered delays in obtaining vital new state-of-the art devices. Vertically integrated Japanese competitors favored their own computer affiliates in these periods of tight supply.

Semiconductor manufacturers also found themselves threatened by the virtual elimination of U.S. DRAM production capability. They found that DRAMs production processes were "technology drivers." That is, the lessons learned developing and producing DRAMs carried over into other areas. Further, the massive DRAM activities generated a broad economic base that could support the technical and personnel requirements of other devices.

Although these problems were first encountered by smaller companies, even IBM came to realize that it needed to help preserve the U.S. infrastructure. Although the company is the world's leading memory device manufacturer, it also is a huge purchaser of merchant DRAMs. The company did not relish the prospect of becoming dependent on some of its chief competitors -- NEC, Fujitsu, Hitachi -- for DRAMs. Recognizing this situation, IBM undertook a fundamental reorientation of its corporate strategy, began to seek to share its technology and resources with other U.S. companies, and sought to encourage cooperative activities.

U.S. Memories was intended to address the difficulties I have described. It was to harness existing U.S. technologies -- particularly, IBM's state-of-the-art 4 megabit DRAM -- for the broader use of U.S. industry. It was devised to offer an assured, stable supply of state-of-the-art memory devices to computer makers that invested in the venture. Finally, it was intended to increase

competition in the DRAM market by introducing an additional player.

**The Failure of U.S. Memories: Explanations and Implications**

Many reasons have been advanced for the failure of U.S. Memories to attract the necessary investor support. Among these explanations are the cyclical DRAM surplus and concomitant falling prices, the entry of Korea into the field of DRAM producers, the difficult financial circumstances of the computer industry, antitrust concerns, and the inability of the project to move as quickly as was necessary.

While relevant, none of these reasons was primarily responsible for the failure to launch U.S. Memories. U.S. Memories was intended as a long-term project, and the present market downturn likely would have long since passed by the time the venture's fabrication lines were ramped up. Korean entry is significant, but not different in kind from the large Japanese producers already dominating the market. In spite of tight finances, the resources for the project were available if a broad range of companies had invested. Antitrust issues were difficult, but not insurmountable. The slow progress of the venture in getting off the ground was a symptom, not the cause, of the venture's failure.

Mr. Chairman, the primary explanations for the failure of U.S. Memories are the inability of many in the U.S.

industry to confront long-term, strategic problems and a deep-seated reluctance throughout the industry to undertake cooperative activities with traditional rivals. Most of the companies I approached conceded in principle that U.S. Memories was a sound concept, yet they ultimately weren't willing to invest. This was the result of a short-term, "go it alone" attitude, and an adversarial mindset towards suppliers that the companies simply could not transcend.

At root, the American businessman still believes in the spirit of "rugged individualism." This attitude has brought America a long way but, like every viewpoint that becomes dogma, it can be taken too far. Competition is a good, healthy and necessary thing for high technology companies, as it is for society at large. But there are areas and instances when cooperation is necessary if individual efforts are to bear fruit.

The high-technology sector in this country must be willing to cooperate to ensure the viability of key enabling technologies, the existence of which are essential to the continued success of individual entrepreneurial efforts. Unfortunately, the failure of U.S. Memories shows that the sector is not yet prepared to recognize and act together to confront long-term, strategic problems.

Launching a major cooperative venture in manufacturing with several industry participants is a formidable challenge. SEMATECH paved the way for cooperation in the semiconductor industry by successfully undertaking joint

research and development in generic manufacturing technology. U.S. Memories represented a long step beyond SEMATECH - a far reaching effort into joint production itself. It came very close to succeeding.

If ventures like U.S. Memories are to realize their potential, the U.S. government must help to create an environment in which they can succeed. A variety of measures will be helpful immediately:

- Adopting a permanent research and development tax credit;
- Adjusting U.S. antitrust laws to facilitate joint production ventures;
- Reducing the U.S. budget deficit; and
- Lowering the cost of capital.

Equally important as these concrete measures, the U.S. government can lead the way toward placing greater emphasis on technology development and improved manufacturing as crucial means for enhancing our nation's standard of living and national security. In such an environment, U.S. industry will be able to respond strategically, restructure to meet foreign competition and regain its international preeminence.

The CHAIRMAN. Thank you.

I'm going to reverse the order and go last this time on our side. Senator Bryan.

Senator BRYAN. Thank you very much, Mr. Chairman.

Where do we go from here? We tried. For reasons that you've described we didn't make it. That's not terribly encouraging for those that might follow. Where do we go from here?

Mr. KANE. Well, you have two choices. You can decide we failed and there's a fundamental problem that can't be fixed and you then pack it up and go home and we can read the OTA report until we're blue in the face and decide we've lost. That's not my style and hopefully not our country's either.

I was encouraged by an article in today's New York Times in fact that some companies are trying the idea of putting together a consortium for flat panel displays primarily for original use in laptop computers, eventually in military systems and televisions as well.

In concept, it's not much different than what we were trying to do with U.S. Memories. I'm pleased to see that some companies are at least willing to try that and haven't totally lost heart by our failure.

So I think we need to keep trying. I think it is critical for that environment that I described to be improved. While I don't believe that it would have made a big difference if the Government had come in in the case of U.S. Memories and said, "We'll add $100 million to the equation." I don't think that was critical.

But I do believe that for future ventures more than simply putting money into a production venture, creating an environment that will make a difference in terms of the investment tax credits, in terms of the cost of capital, in terms of reduction of concerns with regard to antitrust—those things can make a difference. They take away the potential thorns in the issues that make it easier for companies to think, yes, there's value in cooperative efforts.

Senator BRYAN. Well, a lot of us want to be helpful and hope that there will be others that will take up those pieces.

Let me sharpen the focus just a moment. Antitrust. The chairman mentioned it's been created here in the Congress for some time. Do you have the specifics of a proposal or is there a proposal which you would invite to our attention that you think would alleviate the kinds of concerns that were one of the irritants, not the cause per se, but one of the irritants that created at least some of the uncertainty that you need to eliminate?

Mr. KANE. There are, as you probably are aware, a number of bills that are currently pending in the House right now, two in particular. One is Congressman Fish's bill and the other is Congressman Edwards' bill. Other than the numbers on the top of the bills, I haven't been able to figure out what's different about them, but I think their basic concept makes sense, which is really taking the extension—it extends the ideas of the National Cooperative Research Act of 1984 and provides for the opportunity for manufacturing joint ventures as well.

I think those kinds of things clearly provide an opportunity for people who are doing things that violate the law to still be pros-

ecuted but creates an environment in which companies will be able to work together.

Senator BRYAN. And for joint production?

Mr. KANE. Yes.

Senator BRYAN. Thank you very much.

Dr. Ross, a question for you. Those of us who sit on this side of the table, we go out and we talk to chambers of commerce and we talk to the Rotary Club and the service clubs every time we have a break, but very candidly there's a real credibility gap that we have in the sense I think a lot of people see us in the context of, well, you're just politicians and you're advocating a role for Government to participate in the private sector and what you're really trying to do is enhance your own position and argue for a bigger piece of the action yourself. They see us as having a self-interest in doing so.

I can't emphasize strongly enough how important it is for people like you and Mr. Kane to get out there—I realize you can't speak to every chamber of commerce in America or every service club, but you have the kind of credibility. As the chairman observed in his introductory comments about you, people will tend to believe people like yourself. I must say that I don't sense in talking with the business community in my own State a real energized commitment. I think there's a sense that things aren't going terribly well. I think from a cerebral point of view, yes, we've lost market share. I don't think people realize how serious this problem is and how soon we must respond and I must say—not in a critical vein to either of you two gentlemen who give your time and appear today—it's damned important for you to help carry that flag and maybe you might have some suggestions that will make us more effective.

Let me end this on a question.

Mr. ROSS. I agree with your comment entirely that we have to be outspoken and we have to spend our time forthrightly describing these problems.

Also, I think we have to deal with this lack of trust, not only among industry to cooperate but between Government and industry. It's a very proper role for the U.S. Government to provide the climate within which U.S. industry can compete within the nation and overseas. The trouble is today that people are suspicious that Government wants to start picking winners and losers and all those nasty things, and there's distrust the other way. When we in industry speak about our need for cooperation with Government, there's also a distrust that what we're looking for is subsidies and handouts and all the rest of it.

I think we all have to work hard on reestablishing the roles and mission of Government and industry and academia for that matter and begin to work together more and trust one another more, and that's a tough cultural change.

Senator BRYAN. Well, just as I hope we will not be discouraged, I hope the two of you will not and will continue to sound the alarm and send this message across the land.

Thank you very much, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Bryan.

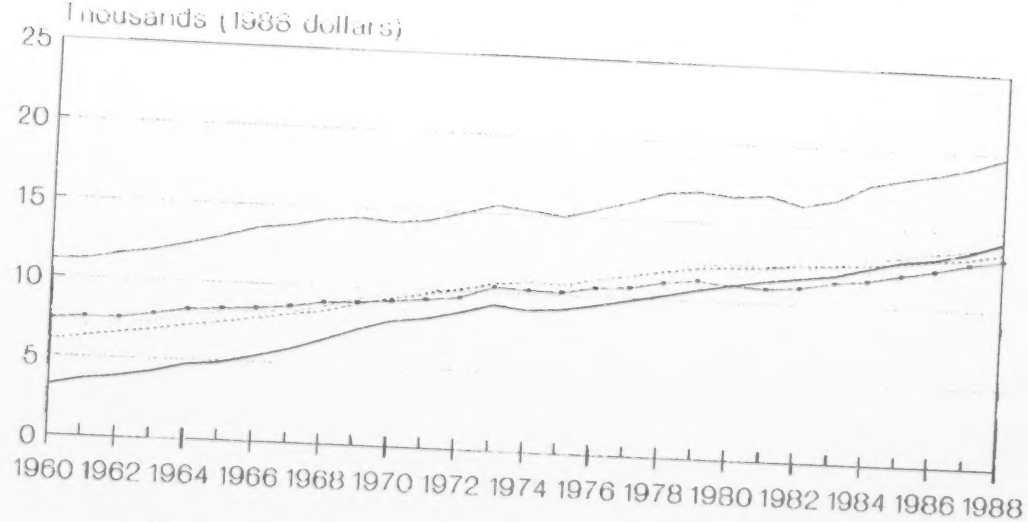
Senator Heinz.

Senator HEINZ. Mr. Chairman, I'd like to enter into the record two charts that were prepared by the OTA for me that didn't get into their publication. The first is a chart that shows GDP per capita and average annual percent increase. If you look at it, it looks pretty good. We are the top line, and everybody else is below. We are maintaining our margin, but if you look at the little teeny statistics down below it doesn't look quite as good. We're not growing as fast as Japan, West Germany, France or the United Kingdom, but who cares most of the time as long as the picture seems to look good.

Now I have to tell you this chart does not reflect the exchange rate issues that we discussed earlier, and I hope maybe OTA can adjust for that.

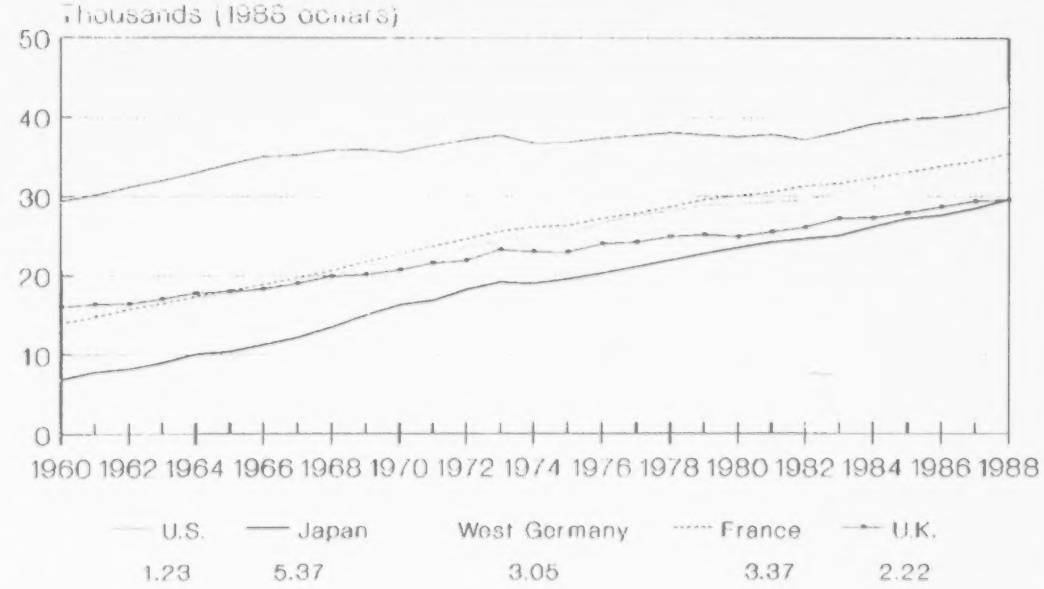
The second one is kind of interesting. It's one I asked them to do on GDP for employed person, an average annual percentage increase. Because of the large number of women we've had coming into the workforce, unlike most other countries, it turns out that gross product per capita is very misleading. Product is produced by workers, not by people, and it shows that we are producing less for every worker to the point where we are almost not much better than anybody else, and worse, we are really losing it rapidly. We are not even half as good as the United Kingdom. We are not even one-third as good as France or West Germany. We are not even one-fifth as good as Japan. We ought to worry about this. That just goes in the record.

# GDP per Capita and Average Annual Percent Increase




Source: U.S. Department of Labor

# GDP per Employed Person and Average Annual Percent Increase




Source: Department of Labor

I've got a question for Mr. Kane. In your response to Senator Bryan you mentioned that we seem to have some difficulty cooperating. My question is, there is cooperation, currently it's pretty good, at SEMATECH, but not at U.S. Memories. Why?

It would seem to a nonexpert that both of them seem to be ostensibly composed of the same rugged individualistic entrepreneurs. Why does one work and the other not?

Mr. KANE. There's a number of differences. I guess I'm as good as anybody to answer that question since I was also one of the fathers of SEMATECH.

A few differences. First SEMATECH is a not-for-profit tax-exempt R&D research facility working on improvements in manufacturing technology. It is not product oriented. It has no product output. Its output, if you will, is knowledge, which it then passes back to the member companies who will benefit first from what SEMATECH does. The member companies are also not investing in SEMATECH. They are making annual contributions to the ongoing cost of SEMATECH, which is being shared with the Federal Government.

U.S. Memories, on the other hand, was, God willing, a profit-making venture with a product orientation where the companies were being asked to make an investment in the future, not paying for today's funding requirements but making an investment as they would in any other commercial venture that they would be involved in. So that's one thing.

The second thing also that I think is a lesson to be learned, it took a while to get SEMATECH off the ground because in fact we were dealing with a group of companies, 14, who were fierce competitors with one another, didn't trust one another very much, and other than going to trade association meetings they had little to do with one another, and it took us a while to get to the point where we were able to focus on the fact that the needs of the industry were more important than the need of any one company from a competitive standpoint and that they could still compete with one another fiercely even though they participated in SEMATECH. That timely process took a while to happen.

In the case of U.S. Memories, those companies who were participating in SEMATECH and had learned that lesson were the ones that were quickest to be ready to sign up to work with U.S. Memories. Where we failed to get the support were from the computer manufacturers in the United States other than Digital Equipment and IBM who are also participating in SEMATECH, but companies like Compaq or companies like Tandem, Apple, etc., who are fiercely competitive with one another hadn't learned those kinds of lessons that we learned in putting SEMATECH together and weren't quite yet ready to make that leap, if you will. So there are those kinds of differences.

Senator HEINZ. That's very helpful. And it ties in neatly with a question I would pose to either of you, which goes back to the question of higher entry costs and more rapid product life cycles in this industry in particular.

One of the things that I remember from Liar's Poker is the apparently apocryphal bet between John Gutfreund and Mr. Meriweather, $1 million, one hand, no tears. Meriweather, who was

apparently one of the best traders in the world, said No, because $1 million to him was a lot of money. To Gutfreund, it was a lot less.

The size of the bet does matter. We will all bet a dollar on this or a dollar on that, but when someone says how about $100, suddenly you're talking about real money and we begin to worry.

What that tells me is that above all what the Government has to be doing, if we're doing anything, if there is a legitimate role for us, is to look for a strategy that lowers the risk of making the bet.

Now I've got a different theory as to why your enterprise didn't make it. It's a reason you didn't mention, and the reason is that our Government has said in so many words, if you are an American industry and you are experiencing competition and the competition is unfair in the form of dumping or the result of industrial targeting strategy by Japan, tough luck. We're not going to protect you against that, and to prove is we're not going to enforce the semiconductor agreement that was the equivalent of a consent agreement for the antidumping practices that were proven against Japan on chips.

It proved it a second time by saying we're not going to enforce the supercomputer agreement. It's not being enforced.

Third, it said we're not going to enforce the science and technology agreement. It's not being enforced.

My view if I were a member of your consortium would be, gee, Mr. Kane, he's a great guy, knows what he's doing, but our Government doesn't, and we'll put this money in and, yes, we're going to have some problems working together and that doesn't make it any easier, but what have we got if we do everything right? The answer is, the chances are we are on our own and we are going to get clobbered by one of those other big juggernauts where the Government signals in a variety of ways that they are supportive, that there's a safety net and they're not going to let the enterprise go. That's my theory. I may be wrong.

Let me ask both you and Mr. Ross whether my theory is wrongheaded, right on or maybe in between, plausible but unprovable.

Mr. Ross. Well, I believe Andy Grove from Intel said the other day that he feels sometimes he's fighting two governments, the Government of Japan and the Government of the United States, which I think is the point you're making.

I believe you are absolutely correct, that there is an environment that can be created by the Government that either can appear to be supportive for people risking their careers and risking their capital or can be counter to it.

I think it's important for the U.S. Government outside of subsidies, outside of paying for R&D, to do everything it can to create that supportive environment. Whether that's a matter of enforcing laws, whether it's a matter of reciprocating where people don't give us a level playing field, if it's a matter of the interpretation of the antitrust laws, if it's a matter of encouraging people to get together rather than making them wonder just where the Department of Justice will come out—all of those things can add up to making the difference between a decision of shall we go together on this, shall we take a risk or shan't we. I think you're absolutely right.

I'd like to add one thing to your cost of reentry. It's not just a question of knowledge industries where you can get behind very,

very rapidly and lose the knowledge. It's also a question of economies of scale.

Senator HEINZ. I did mention that just a second ago.

Mr. ROSS. It's very, very important. You cannot compete in these high knowledge industries if you're running at one-third the volume let alone one-tenth or one-thousandth the volume of your competitors. And getting back into a high volume production in something like semiconductors is almost as tough a barrier as regaining the knowledge which you can lose.

Senator HEINZ. And I hope anybody who cares—and I notice that it's a dwindling audience here—will look on pages 14 and 15 of the OTA report, table 2, figure 16 and figure 17, which demonstrate visually—and figure 18—exactly what is taking place in a number of high tech industries—how things might appear OK on the surface in terms of an individual company's sales volume, but in terms of market share and economies of scale things are clearly going to hell.

Mr. ROSS. Yes.

Senator HEINZ. Mr. Kane.

Mr. KANE. Let me try to address your question in two ways. There's not a doubt in my mind that if some of the environmental changes that I discussed earlier had been in place when we were starting to do U.S. Memories, the atmosphere and the desire and willingness on the part of companies to cooperate clearly would have been different in my view.

Also an indication of what we could have expected in terms of cooperation from the Federal Government affected the way we got this thing started. There is no doubt in my mind that if we could have had either some direct or indirect financial support from the Federal Government for U.S. Memories it would have made it a lot easier to get it off the ground. But we were absolutely convinced that we would have run into a very solid wall on that subject, would have spent 6 months trying to argue that out, even if we succeeded, and lost valuable time doing what needed to be done, and we believed we could do it without it, so we said let's go ahead and do it without it.

Clearly if the environment was different and we knew we were going to get the kind of support that we should have been able to get, we probably would have approached it differently in that sense.

The one place, specifically as it relates to U.S. Memories, that I disagree with your statements, although as a general point it's clearly correct, is that the companies looking at their investment in U.S. Memories, recognizing that there are always risks in these kinds of things, looked at a business plan that they were given when we finally made all of the adjustments that were necessary to ease their concerns, and one that had relatively low risk with relatively low cost to them as individual companies to invest, and one in which we were able to clearly demonstrate that within 3 years we could have been cost competitive with the best of the Japanese producers of DRAM's in the world.

If you can be cost competitive with your best competitor, then as prices fall, unless they choose to price below cost, you can stay with them and compete in the world market. If they chose to compete

below cost, then you have some laws, however inefficiently managed, but laws that exist to help you with that kind of a process.

So we were quite confident that we could have in fact won the day with our plan on that basis.

Senator HEINZ. Mr. Chairman, thank you very much.

The CHAIRMAN. This is a critical discussion and it needs to continue. I want to pursue a couple things with you. This committee really has the broad charter in the Senate to try to understand the bottom line of what has happened to us economically, and it's very interesting what the actual literal definition of what each committee's assignment is but it's about a two paragraph summary, so we have to do some interpretation. But it's clear that this question of trying to figure out what the bottom line economic and financial impact of our competitive position and its erosion is all about falls here.

We've had a number of other hearings going on across the hill and around the Senate today but I think we still have quite a good turnout considering the conflicts.

If all the members of this committee were here that presently constitute this committee, you would see sort of a powerhouse membership, but we have a very strong committee here in terms of who now serves on both sides of the aisle and a growing level of concern about these issues.

I am determined to see the committee collect these questions and issues into some coherent strategy alternative and find a way to bring them forward. Significantly, Senator Heinz and I both serve on the Finance Committee as well as here and so the question of the parts of the package that might relate to tax law changes and incentives and so forth are something we can get at directly in another committee.

I want to make one other observation and I'd like to make a suggestion and ask for your response to it.

I want to thank the press members who are present at this hour of the early post noon hour. I'm so struck by how hard it is to get public attention on these kinds of questions. They are profoundly important. Our ability in the end to pay for anything in the private sector or the public sector, drug programs, people buying houses, sending their kids to college, or whatever it is—it all depends upon our ability of our economic system to produce income and to produce wealth that we can spend and invest in various ways.

So you'd think this would be a topical issue that would fill a room like this, and I'm so struck as I watch the press coverage on the Trump domestic problem where press people are literally in physical danger because there are so many of them and they are crawling over each other. The attention is so intense that it is literally just incredible to watch the volume of press coverage, and not just by the daily news but by the New York Times and sophisticated news outlets that presumably know how to follow the news. And I'm reading about the New Zealanders right now who are just being inundated by a wave of press people who are hitting New Zealand in the case of the young Morgan child.

Mr. KANE. Unfortunately, competitiveness doesn't sell newspapers.

The CHAIRMAN. Well, it doesn't seem to sell newspapers, which tells you something about the newspapers and the news business these days, that it's a dollar business and it's an entertainment business increasingly—I say that with some regret—and it's very tough to get a focused and incisive and continuing and penetrating look at what's happening to America and what's happening to our future.

Despite all of that, despite the fact that I don't think President Reagan ever tuned in on the work of his own commission on competitiveness 5 years ago, and I don't think he could pass a three question exam on that subject and 5 years have gone by and we're still trying to get the Government, the private sector, and the public to engage on the urgency of this problem—we have to stay at it.

Here's an approach that I want to try to use. I think we need to develop a legislative package—I don't say that because I'm wedded to legislation, but it has to become tangible. It's like making a DRAM or something. If you don't have a product, a strategy product, it's hard to get much of a debate going. So I'd like to develop the strategy product off of these recommendations and put it in a usable form. Some of it may be as general—not general because this makes it specific—but setting national achievement goals out over a period of time. Other parts may be more discreet in terms of saying we need to change the structure of Government in a certain way or we need to change the tax laws in a certain way or change the antitrust laws in a certain way so that there would be component parts in a larger strategy.

I'll tell you what I need to get this done, and I think we can get it on a bipartisan basis and it should be done that way. There will be some resistance from the administration because I think there are people down there who don't think there's a problem or if there is anything that involves Government being part of the answer, it will make the problem worse. They become an impediment in any serious kind of effort. Hopefully, they won't be a majority and at some point we will be able to get the administration to sign on to something along this line.

We need some additional help and what I'm thinking of asking or creating is a private sector group of about—I don't know how many people I'm talking about right now, maybe half a dozen—really smart people who could as volunteers work with us for the next 90 days in a group effort with the professional staff here and with the senators who have a serious interest in this, but who could be detailed to work on this full time so that we could really craft and take the best strategy ideas and put them into a legislative initiative and have it ready to put on the table for debate to sort of force the issue and get this thing moving at a faster pace.

I'd like to ask both of you to think about that idea, about whether you could help us put our hands on six or seven really top-notch talents. They could be in a lot of different capacities now, but somebody who could come in and work with us and help us assemble the best thinking we can in terms of forging a package of this kind. We have very good professional staff people here. They are not speaking today, but they are very deeply involved in this.

I would think we ought to set as a goal for ourselves planning on having something done in roughly the 90-day time frame and put it on the table and say this is where we need to go and see if we can't get more people engaged in a serious way in a debate.

I think there are problems on the business side. Senator Bryan referred to the question whether there's any compelling sense of urgency broadly shared in the business sector out across the country. That seems spotty to me. I don't see the kind of real sense of urgency out of the private sector broadly based that I think we need.

I know Donald Peterson from my home State company Ford Motor Co. is quoted in today's paper as expressing some of his concerns along these lines and, of course, he's stepping out of his position and I hope to have him engaged in this effort along with yourselves and others.

I would really like some help from you on doing this. In other words, I spent 3 years with IBM, not 27 years, but sometimes you have to crosswire an answer if you want to get from A to B or from A to D and you don't have the time to go through B and C, so I think we've got to find a way to put together a relatively simple, straightforward, compelling strategy package that is put in a legislative form that really sort of brings all of this down to a specific kind of vehicle that we can presumably support and get behind. It won't be precisely to anybody's liking and of course this gets into the problem of how do you keep people in a consortium who have somewhat different points of view about things. I'm prepared to accept things that won't precisely be to my liking, but I want a package that basically frames this issue and get it out there before we lose the future.

If we don't do it, I think the kids that are coming down the track—not just the 4 and 5-year-olds but the 15-year-olds and the 10-year-olds and even the 20-year-olds are going to be asking us 10 years from now how we missed the turn, where were we back in 1990 that we couldn't wake up and do the things that would have given them the kind of opportunity for an economic future that most of us or our current generation have had the great privilege of being able to enjoy and to have. Because it's getting away from us and it's going to get away from them and by the time we wake up it's not going to be easy to get back if we can get it back at all.

I don't want us to miss that turn and I very much appreciate the leadership that both of you have given professionally because you've been way out front. You've helped lead this effort and been very helpful to those of us here who care deeply about it.

Now that I have the chance to be the chairman of this committee, I want to see this committee step into that vacuum and try to produce a package of the kind that I'm describing here that can help us make some faster progress in terms of actually getting something done.

So I'm going to ask you if either of you might be able to identify or even detail somebody that's worked with you in the past who can come in here and help us for a while just to get this one assignment done. And I will ask some others as well.

Let me just touch on a couple of other things and then we'll finish here for the day and I appreciate your patience.

With respect to this question of the Japanese companies operating as a cartel shortly after the U.S. Memories venture collapsed, Dr. Ross, you state in your testimony on page 7 that our foreign competitors, particularly the Japanese, have demonstrated their ability to cooperate so as to exercise market power control both as to the access to and the price of critical technology. You made a reference, Mr. Kane, to that as well in terms of what we saw happen.

Are the Japanese companies engaging in cartel-like behavior and have you fellows seen enough to be able to make that judgment and say so directly?

Mr. Ross. Well, I think the word cartel is a little strong, but I think there's no question that the Japanese industrial community works together with the civil service, with the executive branch, with MITI, in what they perceive to be the interest of the nation. And I think if that forces them to pick and choose who bids on what contract and under what circumstances, I believe that is done. But it is done as a cooperative understanding among people who are working in the best interest of the Japanese society.

The CHAIRMAN. Isn't that a de facto cartel? I know you don't like the word and you're a measured man, but isn't the practical effect that we're getting a cartel effect?

Mr. Ross. As I said in my testimony, they are very effective at working together in the interest of the nation and their industries, yes.

Mr. KANE. I think Ian is being kind. I would say yes. Just two comments relative to that. I thought it was rather interesting that within a week after we announced the demise of U.S. Memories on January 15, five of the major Japanese memory manufacturers announced that they were cutting back on production of one megabit memory. I'm not convinced that they did it tied to U.S. Memories demise, but the fact that they all did it within a week of one another and they argued, well, we were all looking at the same data by ourselves and came to the same conclusion—I find that remarkable. Someone from the press asked me that week whether or not I thought that the Japanese had a cartel and my response was, "The only difference between the Japanese and OPEC is that OPEC is nice enough to tell us when they have a meeting."

The CHAIRMAN. Well, I think it's a serious problem and we're going to do something about it and I appreciate the bluntness of your response.

Let me move to another item. Dr. Ross, on page 7 of your testimony, you say that it's essential that the United States maintain a microelectronics industry. The consequences of not doing so, you note, are best seen from the perspective of national security, which you stress, because of the qualitative edge in advanced weaponry and other military hardware that is obviously down the stream from that.

You further state that our supplies of such products "should not depend on foreign trade flows that can be disrupted and should not depend on foreign owned manufacturing even if it's physically based in the United States." That's a quotation.

I think most people can understand your concern about foreign trade flows being disrupted, but I think it's very significant that

you also express a concern on foreign owned manufacturing facilities based in the United States, and I would like you to address that part of it.

Mr. Ross. My concern is multiple. First, what percentage of the value in the product is added in the United States and very frequently foreign owned companies are assembling things in the United States for various reasons, but the sum of the more valuable high technology components are supplied from overseas.

Our second concern is where is the research and development being done? I think it is true that although the Japanese manufacture in many, many nations, the vast majority of their R&D is still done in Japan. So that the technical base, the knowledge base, remains in Japan and to the extent that they are manufacturing here it is not resident in the United States.

Then I think there is a question of what is the motivation of the owner. I do happen to believe that there are patriotic sentiments and if your owner is in the United States they are interested to some extent in the welfare of the United States. If the owner is somewhere else, they are interested to some extent in that nation's welfare rather than ours. Those are the kinds of things that concern me.

The CHAIRMAN. Mr. Kane, what are your views on that?

Mr. KANE. I agree with that. I think there's one thing we need to focus on and that's the fact that any time we have ever managed to get the United States Government interested in doing something to help industry or R&D activities, et cetra, or any time we ever get them alarmed about the problem whether they ever do anything about it or not, we have simply up to now only been successful when we can wave the flag of the national security, all of which is true. The only reason we were able to get funding and support for SEMATECH was because we had the help of the Defense Department to do that. And I don't take away that support at all.

It's time now, in my opinion, very much related to the piece of work, for example, that you said you would like to have the staff do over the next 90 days—it's time now to broaden this so people know the major economic effects that we are talking about if we don't take some action.

If the microelectronics industry or the electronics industry in the United States becomes a second class industry, we are talking about the single largest industry in the United States that employs more people and has more revenue than automobiles, steel and aerospace combined. It is big. And the economic effect to every John and Jane Doe across the country will be dramatic if that industry goes by the wayside. That's the message we need to get across.

There's nothing wrong with relying on national security as a reason for doing something, but we need to broaden this so that more people have a better understanding of what it is we're doing.

The CHAIRMAN. National security, as I see it, is fundamentally economic security.

Mr. KANE. Absolutely.

The CHAIRMAN. You can talk about weapon systems and projecting force around the world and all this business and that's a part of the puzzle, but it all has to rest and depend upon your economic

base. If you've got an economic problem that is causing you to slide backward over time—the Russians are a classic example. They are armed to the teeth with the military capability and their economic system has collapsed. I think there are human and social elements to the collapse as well, but we don't have to look very far to find a contemporary example as to what happens if you're not paying attention to your economic fundamentals.

This is a very hard thing for the United States to understand because we all live with the John Wayne mentality in terms of the country as a whole, that we're always going to be entitled to win or be in first place or to get the Olympic gold or however you want to put it, and to puncture that and to get past that mythology and hubris to get to the point of the urgency of the erosion of our economic position globally and especially in strategic industries is absolutely at the heart of our future.

I must say, as I sit up in the Budget Committee, and as we hear the discussions about how much of this or that for the drug war, how much of this or that to solve the housing crisis and get people off the hot air grates and so forth, all of these issues depend ultimately—their solution—on economic strength, whether you do it in the public sector or the private sector or some blend of this or that. If you can't pay for it, if you don't have the national income, there's absolutely no way in the world that we're going to be able to solve these very compelling problems that we've got all around or around the world.

Here we've got an opportunity in Nicaragua right now and we're not sure we've got any money to be able to go in and do the things that would give democracy and free markets a chance, or a lot of other places over in Eastern Europe where we need to be making some investments right now. We need to make a lot of investments at home.

This technology assessment report today on education obviously will focus it there and you've mentioned a number as well.

So I think there is nevertheless developing a kind of rough consensus within the Congress, within more and more thoughtful people in the private sector, that time is running out on us, and that we have got to have a strategy and that an ideologue here or there in a given administration or a given cabinet department or in a given key spot in the Congress can't hold the whole country up from making the adjustment that it has to make to maintain its international leadership position.

So I think the time is right to push this debate forward. Now we need a package. We need something that makes it tangible and real, and that we can go out and sort of market intellectually in the market as a practical matter.

So we are going to try to put that together, but I do need your help in a direct way. I don't know in terms of your own time—I don't ask to impose on you, you've got other important duties to do, but if you can help us find the talents that we can have for a period of time in here on a volunteer basis to get this work done, we'll get it done. We will put something out and push it hard and I think it will start to make a difference.

Mr. KANE. That's good.

Mr. ROSS. Yes.

The CHAIRMAN. I'm going to give you some other questions to respond to for the record. I know a number of my colleagues had questions that they wanted to pose and could not because they were stuck in other committees this morning.

I want to thank you very much for being here today and I want to thank you for your leadership nationally.

Just one other personal observation. I was working on a doctoral degree at the Harvard Business School a few years ago in a field called "Business and Government Relations" and I worked for a fellow called Paul Cherington that you may have known. He was a wonderful man and he has since died, but the whole thrust of his work and the work that I was doing was to try to figure out how we could get business and Government and labor to sort of think together in this country in some sort of a team fashion. In other words, how do we sort of think of the country as a whole and not just a lot of bits and pieces at war with each other.

So hopefully we are at a point here where we are going to be able to start to think in some kind of a team America concept before it's too late, before we wake up some day and find we're all working for somebody else and owned by somebody else.

Gentlemen, thank you very much for coming.

The committee stands in recess.

[Whereupon, at 12:35 p.m., the hearing was adjourned.]